MILLIKEN CHAPMAN RESEARCH GROUP INC.

Final Report

Forest Service Research: Dealing With The Issues Underlying Concerns of Competitiveness and System Responsiveness

June 30, 1988

Study Project:
ASSESSMENT OF THE COMPETITIVENESS
OF FOREST SERVICE RESEARCH

-Prepared for-
USDA Forest Service
Rocky Mountain Experiment Station
Fort Collins, Colorado
Under Contract No. 28-K7-433

-Prepared by-
Richard L. Chapman and J. Gordon Milliken
Milliken Chapman Research Group, Inc.
6631 S. University Boulevard
Littleton, Colorado 80121

Table of Contents

Foreword

The focus in this study has been upon the Forest Service Research's "competitiveness"-- for resources and scientific standing, and upon "responsiveness"-- to the needs of those who are clients or users of Forest Service research. Forest Service Research (FSR) does face serious, important challenges, as outlined in this report. However, the Forest Service has the capability to meet these successfully, if it chooses to do so. During the course of the study, and in this report, the MCRG Study Team has reviewed other domestic analogues for FSR consideration, and suggested those. The study team did not examine foreign candidates, but based upon late interviews, would suggest that it would be worth looking at forestry research in Canada which has a governmental and private enterprise system most similar to that of the United States. Particular attention might be given to their consortium, Forintech (involving Federal, state and private industry organizations) and the Pulp and Paper Research Institute of Canada.

In using this report, the authors would like to suggest that readers give attention to appendices D through H which are updated versions of Task Reports I through V. Your attention is especially drawn to the revised data on competitiveness found in Appendix G.

The Forest Service Research organization has a great deal in which it can take pride, including the spirit and motivation of its researchers and supporting staff. Throughout the course of interviews and data collection the MCRG study team found a universal goodwill toward Forest Service Research among USDA officials, officials of other Federal Government agencies, representatives of industry, academia, and professional organizations or trade groups. Without exception, those interviewed were willing to describe their perceptions of "problems" in Forest Service Research. This was always done in the spirit of overcoming these problems in the best interests of both the Forest Service and the forestry community.

Finally, the authors wish to thank the scores of Forest Service officials who took the time to provide information to the study team. It was a pleasure to work with the men and women of the Forest Service who provided information, arranged interviews, sought documents or other sources of data, giving their full cooperation in a friendly and open fashion. Our special thanks go to our two project monitors in the Washington Office, Peter Roussopoulos and George Moeller, who provided outstanding guidance and assistance, all with good-natured patience.

The study team takes full responsibility for the material in this report and the suggestions for further action.

Richard L. Chapman, Ph.D.
Study Director

FOREST SERVICE RESEARCH: DEALING WITH THE ISSUES UNDERLYING CONCERNS OF COMPETITIVENESS AND SYSTEM RESPONSIVENESS

Background of Concerns Over Competitiveness and System Responsiveness

Within the general context of the forestry research community the Forest Service rates high in terms of both scientific standing and ability to attract resources. Indeed, research leaders in the Forest Service and outside of the Forest Service generally concede that the Forest Service Research (FSR) program is preeminent among natural resources research organizations when considering these two primary measurements. With respect to responsiveness, FSR users broadly acknowledge that the Forest Service usually is sensitive to their needs (within constraints of available resources) and that, with a few exceptions, the system is responsive and research leaders exert every effort to meet those needs in a timely fashion. In spite of this positive view of FSR and its reputation for being responsive, why does there remain a discomfort and air of self-doubt within the FSR organization--and among those affiliated with forestry research in the larger community?

The discomfort appears to be rooted in a concern that FSR is in danger of losing its capacity to provide scientific leadership to the natural resources community, beyond the forestry research community and the Forest Service itself; and that it is poorly positioned to attract the additional resources most proponents believe will be necessary to make significant progress in the future. They see this as partly a resource problem, and as an institutional one in which the historic system for conducting research within the Forest Service is showing signs of organizational atherosclerosis, reducing the potential capability to respond to emerging challenges and needs.

These concerns are not without substantial foundation. The FSR budget, although not reduced in current dollar terms, has reached something of a plateau, and is growing at a slower rate than the cost of doing business or the increase in budgets for other USDA research organizations. At the same time facilities and equipment are growing older, are rather widely scattered, and attempts to consolidate programs to assure a quality base in the face of restricted resources have been only partially successful. Several senior government officials, outside the Forest Service, have suggested that, without a substantial push by Forest Service leadership or some high-priority national requirement, the budget for Forest Service Research may well have reached a plateau. The study team found no evidence among the senior leadership within the Forest Service that would suggest a willingness to reallocate resources within the Forest Service to provide a greater

proportion to the research function, nor a willingness to make a significantly greater effort to obtain additional resources for the research function. Forest Service leadership remains to be convinced that increased emphasis upon the research function is vital to the Forest Service.

The MCRG study team believes that a fundamental "missing element" to a resolution of these concerns is an apparent lack of consensus within FSR (and among its leadership) as to what constitutes the principal mission of Forest Service Research. As noted in two earlier task reports, there is no agreement on whether Forest Service Research should be primarily directed toward: (1) being the preeminent research organization within the Federal Government for natural resources research, or (2) serving the National Forest System, with the applicable research flowing from that to other forestry interests. It is evident to everyone in the Forest Service and outside that the current level of resources cannot sustain both goals.

Review of the Forest Service Research System's Responsiveness

The summary assessment on the effectiveness of FSR program change mechanisms was succinctly stated in the Task III report, "Basic change in the structure for research planning and decision making is not required and would not materially improve responsiveness nor lessen the challenge of hard decisions." That optimistic conclusion was tempered by noting two deficiencies (of practice rather than structure), and two caveats.

The deficiencies were: (1) a relative reluctance to change; and, (2) weak outreach to the broader scientific community. The two caveats were: (1) the need to press ahead with developing and instituting a mid-range planning process; and, (2) developing a clear consensus on the mission of Forest Service Research.

In addition, six factors were posed which tend to limit responsiveness—two essentially external, and four within the power of the Forest Service. The external factors are: (1) the low priority given to natural resources research across the Federal Government; and (2) the mechanical fashion by which affirmative action goals are cascaded down from top levels of government to field activities. Those factors over which the Forest Service has considerably more influence are: (1) the tendency to avoid hard program decisions when they may hurt individual members of the Service; (2) the conservative, somewhat rigid application of the panel performance assessment system; (3) the combination of substantial local autonomy among the Research Stations and ambivalent role of the Washington Office; and, (4) the practice among Research Stations of exploiting local political ties to bypass or overcome Washington Office decisions. All of these tend to weaken the consistency and adequacy of response to the need for program changes. But they do not signal the need to substantially change the fundamental structure of program change mechanisms.

At this point it is useful to turn back to the Task I report on literature relevant to the study. That report identified four themes in the extant literature which should now be reviewed in the light of information developed during the study: (1) R & D must have a continuing role in top-level

management; (2) the R & D organization must have an appreciation for user needs/market orientation; (3) the structure and processes for R & D must fit the organizational environment; and, (4) the R & D organization should set goals and priorities, and judge results with an eye to its own strengths and weaknesses.

R & D must have a continuing role in top-level management. The literature clearly revealed the need for a research charter which was characterized as a "shared understanding of the mission that research is expected to fulfill." [Task I Report, p. D-5]. The point made was that the Chief Executive Officer and the Research Director need to be "mutually in tune" with respect to what can be expected from the research organization. This reemphasizes the importance of FSR dealing expeditiously with developing a consensus on a mission statement and assuring that there is a mutual understanding and agreement with the top management of the Forest Service with respect to it. Beyond having a basic understanding grounded in a mutually understood charter for research, the R & D Director (here read Deputy Chief for Research), if he is to have a continuing role in top level management, must work with his/her colleagues in such a manner as to be perceived to have the best interests of the general organization at heart--and not to be solely an advocate for the research program.

The R & D organization must have an appreciation of the user needs/market orientation. The study team's findings suggest that this is not a general problem for FSR. With some exceptions, there appears to be reasonable responsiveness as perceived by research users. However, there are two areas to which FSR needs to give some attention: (1) to reexamine the adequacy of the FSR outreach to identify research needs and their relative priority among its clientele; and, (2) to be cautious in developing its research mission statement so that potential users to be included among its clientele can be properly served.

The structure and processes for R & D must fit the organizational environment. Both the structure and the R & D processes within the Forest Service appear to have "grown up" over time. By and large, the Forest Service appears to be relatively comfortable with the basic structure and processes for research as they now exist. This study has identified some areas with respect to structure and relationships which should be reviewed for possible modification or change. In that process of assessing various options for change (a number of which are suggested below), it would be useful for FSR to ask the question: what are the organizational imperatives of the Forest Service? Answering this question can provide valuable input into determining what ought to be the Forest Service Research mission; then, how might it best be carried out?

The Research and Development organization should set goals and priorities, and judge results with an eye to its own strengths and weaknesses. The literature suggests that an important consideration in the process of setting goals and priorities is to understand the R & D organization's own strengths and weaknesses. Clearly, when new research areas are developing, an organization may have to overcome current weaknesses by building them into strengths through commitment of additional resources. However, although the

Forest Service has made several reasonably successful attempts to create clusters of "critical mass", it appears to have some tendency to overreach in trying to cover research areas with insufficient resources. Experience from the commercial world suggests that a research organization is more likely to be successful if it carefully selects the scientific/technological fields to which it commits resources for their likely high impact in terms of: (1) spinoff to future development projects; (2) technical contributions to the organization's general strategy; and, (3) an objective review and judgement of the importance of these fields by outside experts. [Task I Report, pp. D-7, D-8]. Interviews with researchers, both inside and outside the Forest Service, emphasized the desirability for FSR to find improved means for tapping this latter area of advice and assistance.

Finally, it is the responsibility of the research leadership to assist general management by identifying the technological future, its trends, and its possible impact upon the organization's purpose. This needs to be systematic, and to be communicated effectively to the Chief Executive Officer. This function does not appear to be fully met in the current research planning process. It may be that FSR needs to supplement the RPA process by a more highly focussed attention toward emerging research opportunities in the field of science generally. A weakness in the RPA process which makes research planning more difficult is the fact that no priorities have been placed against the nine general program goals. Admittedly, the importance of these goals will vary substantially from one forest system to another across the United States. However, without some sense of priority--both at the national and regional levels--the sometimes mutually conflicting goals of the RPA leave the research organization without necessary direction and purpose.

Issues to be addressed. The study reveals that the fundamental structure of the research decision system is, in general, responsive to user needs and reasonably perceived as such. On the other hand, there are several important issues that, if successfully addressed, can substantially strengthen future responsiveness and effectiveness of the FSR decision process.

- The FSR mission needs to be clarified in order to: (1) provide focus for research planning and management; (2) provide a basis for the rational development of priorities; and, (3) provide the basis for a research structure which fits the overall purposes of the Forest Service.
- FSR needs to address various factors which tend to inhibit or prevent change, or which limit the responsiveness of the research system. These include the operation of the panel evaluation system, the assignment and balance of authority assigned to the Washington Office staffs and to the Research Stations, the institution of a more competitive environment throughout FSR, and wider experimentation with means to deal with user needs on a timely basis.
- A more aggressive stance by FSR leadership is needed: to identify and disseminate knowledge about the benefits derived from Forest Service research; to undertake more systematic outreach to identify research needs; to integrate FSR plans with

those of other cooperators; and, to mutually support forestry research.

Review of Competitiveness Of Forest Service Research

"Competitiveness" refers both to scientific competitiveness and to resource competitiveness, and these two aspects are interrelated. Success in resource competitiveness is a necessary but not sufficient prerequisite to achieving and maintaining scientific competitiveness. Success in scientific competitiveness is an important factor in achieving resource competitiveness but by no means the only factor. The quality of scientists and their scientific accomplishments, plus entrepreneurship, are major determinants of success.

The general perception of the scientific competitiveness of Forest Service Research is high, although this is not a universal opinion. Strongly related to a widespread view that the resources of FSR are inadequate to its mission, there is concern both within and outside FSR that its scientific stature is threatened. Indeed, some observers state that this stature already has declined and that preeminence in certain fields of forestry-related research already has passed to other research performers. Evidence exists that the present state of scientific competitiveness of FSR is threatened by certain trends, already visible, that could continue to reduce the effectiveness of scientists and the quality of science unless corrective action can be taken. These trends include: (1) difficulty in recruiting and retaining scientific staff; (2) aging of staff and some mismatch of staff skills with needs; and, (3) limited success in obtaining political support for the FSR program--related in part to limitations in institutional support, leadership and organizational visibility, as well as to the lack of a focussed support constituency. Both aspects of FSR competitiveness will be analyzed and discussed at more length, below.

Scientific Competitiveness of Forest Service Research

This section looks first at objective measures of FSR competitiveness, and later at subjective perceptions of persons interviewed.

Objective measures of competitiveness. Some FSR characteristics or activities have been measured objectively because they are suitable for objective or quantitative measurement and data could be located. The following characteristics related to scientific competitiveness were measured objectively and analyzed:

Professional journal authorships
Professional journal citations
Leadership in professional societies.

Professional journal authorships, particularly of papers in refereed journals, is a traditional measure of competitive standing in the research community. It relies on quantitative measures rather than measuring the

quality of the research contribution, although the referee review process does screen out papers of least merit. Analysis over a multi-year period of six journals selected for their relative prestige in one of the Forest Service program areas showed that more than one-seventh of the articles had Forest Service authors or co-authors. [Task IV Report, pp. G-14 to G-19]. This is an impressive proportion of articles, particularly considering the relatively small number of Forest Service Research staff compared with those in other organizations active in the same scientific fields (i.e., universities, other federal, state and local agencies, and industry). Forest Service authors consistently represented from twice to more than 10 times their proportion of the members of the society responsible for the journal. Most of these journals have an international readership and publish articles from authors throughout the world's scientific community.

Professional journal citations are indicators of the quality of research contributions, as measured by the number of times an article is cited in subsequent articles and books by other authors. Such citation is considered evidence that the article is noteworthy and serves as an authority for subsequent research findings. Analysis of the Science Citation Index for the 1980-84 period showed a very large number of citations of articles by Forest Service authors which were cited in the world's scientific journals, evidently a disproportionately large percentage of citations considering the relatively few Forest Service Research scientists.

Leadership in professional societies and appointments to associate editor posts of a professional society's journal indicate stature in the professional research community. In one case where professional society membership affiliations could be determined, FSR scientists make up only 1.1 percent of the membership of the Society of American Foresters, yet constitute nine of 19 members of the Advisory Board of Forest Science.

Perceptions of FSR scientific competitiveness. Executives of Federal research organizations, forestry organizations and USDA agencies had a high opinion of Forest Service scientists and their research. These opinions were given without reservation, even when certain other aspects of Forest Service Research were criticized, such as timeliness of response to user needs.

Some Forest Service research managers and scientists have expressed degrees of criticism of their organization, such as acknowledging that some scientists are relatively unproductive and that others conduct research in areas that have faded in importance. Several expressed concern that Forest Service Research has lost some outstanding scientists without replacement by equally promising younger scientists. The problems of an aging scientific staff, obsolete facilities and equipment, and lack of operational funds were widely mentioned as threats to scientific quality. Several mourned the erosion or discontinuance of some of the long-term research programs in silviculture and forest management which had been central to achieving the reputation of Forest Service Research. Despite this critical concern for the future, however, the overall view was one of pride in the accomplishments and reputation of the agency, tempered with considerable concern over funding and other trends that threaten this reputation.

By far the most negative views of the quality of Forest Service Research scientists and scientific accomplishments came from interviews with deans and department heads of university forestry schools. That is not to say that this group of 16 respondents was uniformly critical--all praised aspects of Forest Service Research and three of the deans expressed quite favorable opinions of Forest Service scientific competitiveness. However, several university forestry deans and department heads had sharp criticism of FSR scientists and their research, stating that the former research strength of the Forest Service has eroded through inadequate funding, aging of staff and inadequacy of its scientific quality control, and that its former scientific leadership has passed to the universities.

Although there is no consensus as to what the agency's mission is, or should be, Forest Service Research frequently has been viewed as a broad, multi-disciplinary organization that has the role of the nation's (some say the world's) leader in natural resources research. This view is more often stated in the past tense than in the present. To several observers, Forest Service Research can no longer fill this role. Through lack of resources and a resulting lack of research vitality because of inability to recruit top scientific talent into an aging staff, an overall decline in scientific competitiveness has occurred. These observers consider FSR to be stretched too thin to maintain quality in its various existing research areas, as well as in some new areas (e.g., biotechnology) which it allegedly enters without adequate resources. There is a perception that unless FSR appropriations increase substantially (which is viewed as unlikely in the present Federal budget climate), the agency should cut out some of its programs and facilities and concentrate on others. Of those proposing this, most suggested keeping and augmenting the long-term basic research programs and letting applied research go to industry and universities.

A serious and rather widespread perception is that Forest Service Research is not able to recruit top scientific talent into its staff, both to replace leading scientists who are retiring and to bring skills that will enable FSR to maintain scientific competitiveness, or even preeminence, in a changing scientific world. It is clear that many observers consider this to be a serious present problem and an even more serious threat to future FSR scientific competitiveness.

The problem of scientific recruitment and retention is to some degree masked by the fact that a buyers' market exists for Ph.D. scientists in most disciplines. FSR is now able to be selective in hiring new Ph.D.'s, but even so has difficulty in recruiting the top candidates who frequently favor university careers. It is ominous that this occurs even when the Forest Service is seen to offer many advantages to young scientists.

Several causes have been suggested for the Forest Service's recruitment problem, and that of retention of some newly-hired scientists who resign a year or two after appointment. The first is that the long tenure of FSR scientists, combined with some staff cuts caused by reduced funding, results in a limited number of job openings. Another cause of the recruitment problem is the Federal recruitment process itself, a cumbersome and time consuming process of evaluation and certification that adds four- or five-

month delays to the recruitment process and has resulted in several attractive candidates accepting alternative job offers rather than waiting for an uncertain FSR offer. The decentralization of Forest Service Research among regional experiment stations and laboratories, some rural and remote, is a barrier both to recruitment and retention. FSR salary levels, which are viewed as very attractive to young scientists, become compressed in the higher grades. As a result, FSR is not as competitive in hiring to fill senior positions such as project leaders with specialized experience. The intense emphasis on affirmative action hiring in the Forest Service is widely viewed within FSR and by university deans of forestry as a formidable challenge to recruitment of top scientist candidates. No one openly questioned the desirability of an EEO program with aggressive recruitment of women and minorities. Several reported, however, that White males are not recruited by FSR and are discouraged by university advisors from applying for Forest Service employment.

The autonomy of FSR scientists to work in areas of their own choosing is viewed as contributing to scientific competitiveness. Although scientists are officially circumscribed by their RWU description, which they help prepare, it appears they are given some latitude to do research that does not strictly fall within the description. Moreover, some stations offer small competitive grants to scientists to provide operating funds for small projects of their interest.

The quality control process of FSR relies on peer review, both review of research plans to assure statistical validity and replication, and review of publications before submittal to a refereed journal. Some have praised the process as a model for research organizations and relate it to the FSR reputation for high quality research. However, the process inevitably depends upon the quality of the peers. If there has been, as alleged, a loss of top scientists, the quality control process declines accordingly. Criticism has been made that the FSR quality control system is not adequate for high visibility national research programs such as the atmospheric deposition program (Forest Response Program), and that because of this inadequacy, the Forest Service is not competitive with EPA to obtain congressional support to assume leadership of such programs.

The esprit de corps of Forest Service Research became apparent during interviews and station visits. It is manifested in a sense of personal consideration that is a positive benefit to any organization, and a particular asset to a decentralized agency dedicated to scientific achievement and support. It contributes positively to the agency's scientific competitiveness.

Issues to be addressed. There is little question but that Forest Service Research wishes to avert the threat of decline and to recover from whatever decline has occurred in its scientific competitiveness. This goal raises certain issues which must be addressed:

- The mission of Forest Service Research has not been explicitly defined and no consensus definition exists. The implicit definition of mission is very broad, to be many things to many

people--to maintain historical preeminence in natural resources research, to continue long-term basic research in forestry; to undertake applied research and problem-solving on behalf of the NFS and a variety of other client groups; and to transfer technology to users. Given present levels of resources, this mission cannot be carried out. Should the mission be explicitly redefined? If so, what should the FSR mission be?

- How can Forest Service Research develop a scientific staff with the desired age distribution, the desired distribution of scientific skills, and the desired high level of scientific quality to maintain (or regain) its scientific competitiveness?

- Should FSR establish a formal quality assurance system on the EPA pattern, requiring a comprehensive work plan with specific criteria on experimental design and a detailed quality assurance plan, prior to approval of funding? If so, should the system be limited (as at present) to selected national research programs having high visibility, fixed goals and finite schedules, or should the system be expanded to other FSR programs?

- Should FSR make stronger attempts to centralize its research staff into larger units, having "critical mass" and being easier to administer, at the cost of some local support and perhaps congressional discomfort? If so, should a greater effort be made to co-locate these units on campuses of research universities to promote better interaction?

Resource Competitiveness of Forest Service Research

This section first discusses objective measurements of resource competitiveness and later discusses perceptions of persons interviewed.

Objective measures of competitiveness. The following FSR characteristics related to resource competitiveness were measured objectively and analyzed:

Congressional willingness to fund Forest Service Research
Ability of Forest Service Research to attract outside funding
Success in competition for grants.

The Congress has been less willing to fund Forest Service Research than other USDA research programs, based on an analysis of appropriations between FY 1979 and FY 1987. While the combination of all other USDA research programs gained 2.0 percent in constant 1979 dollars (i.e., purchasing power) during this period, Forest Service Research shrank by 14.8 percent in constant dollars. [Task IV Report, pp. G-2 to G-4].

Forest Service Research has fared much worse when compared with appropriations for the four most favored R & D programs that collectively

receive 92 percent of the Federal R & D budget: national defense; health; space research and technology; and general science. [Task IV Report, pp. G-7, G-8].

Only when compared to the relatively unfavored group of natural resources and environment agencies does Forest Service Research manage to hold its own in appropriations. Yet this group's funding is reduced by 5 percent from FY 1987 to FY 1988. [Task IV Report, pp. G-2, G-6, G-7].

The ability of Forest Service to attract outside funding has grown in response to reemphasized efforts to attract research funds from outside sources--various Federal agencies, state and local governments, the forest products industry, universities, foreign governments and others. Total outside funding has grown from $13.7 million in FY 1985 to $21.8 million in FY 1987, when it was about one-sixth as large as that year's research appropriation. [Task IV Report, pp. G-12, G-13]. This ability to attract outside funding is a measure of competitiveness because it reflects the relative attraction of Forest Service Research scientific talent and facilities versus those of alternative research performers.

Success in competition for grants, i.e., the Competitive Research Grants Program for Forest and Rangeland Renewable Resources administered by the USDA Cooperative State Research Service, is an objective measure of the competitiveness of Forest Service Research scientists. All qualified scientists in the U.S. are eligible to compete. Over the three years of the program, FY 1985-FY 1987, Forest Service Research scientists received 23 percent of the grants awarded, representing $4.04 million or 21 percent of the total funding. [Task IV Report, pp. G-14].

Perceptions of FSR resource competitiveness. There is universal agreement that the Forest Service research program has been negatively affected not only by funding limitations which have reduced the purchasing power of its funds over several years, but also by the earmarking of funds by Congress and by the year-to-year uncertainty over funding levels. Certainly the appropriations and outside funding are insufficient to support the broad mission which FSR implicitly defines for itself.

The severe reductions in funding for FSR during FY 1981 - FY 1985 evidently were made based on a redefinition of mission rather than on a belief that the agency lacked accomplishments or was not well managed. Several sources attribute the funding cuts to a belief by Assistant Secretary Crowell that forestry research should be left to industry and that the primary mission of the Forest Service was to promote the sale of more old growth timber in the West.

Some of the problem of resource competitiveness has been attributed to the location of FSR within the Department of Agriculture and to its relative lack of visibility within the USDA. Forests are a second or third level concern, and forestry research is viewed as an appendage of the National Forest System, if it is visible at all. The circumstance that places all other USDA agencies under the oversight of the Agriculture Appropriations Subcommittee while the Forest Service is under the Department of the Interior and Related

Agencies Subcommittee further removes FSR from the center of Departmental attention.

It has been noted that FSR finds more program support in Congress than in the Office of Management and Budget (OMB) or in USDA. There is continuing evidence that cuts made during the budget building process are often restored in the Appropriations Subcommittee. However, interviews with participants in the process reveal interesting perceptions on why this is so. USDA and OMB appear to disfavor Forest Service Research in funding requests because a good case has not been made for greater funding. Combined with a lack of Departmental attention to FSR, this has resulted in failure of FSR budgets to keep pace with those of USDA research agencies.

Of the 126 persons interviewed, representing many agencies and organizations, none gave any indication that Forest Service Research was viewed competitively or with hostility by anyone. Indeed, FSR was the object of good wishes and of hopes for prosperity. This is rare among agencies, which often are opposed by competitive interests and advocacy groups hostile to their mission. FSR does not need to overcome a negative opinion but must make a more convincing case that its mission is important and deserves more resources, particularly to the leadership of the Forest Service itself. Lack of strong advocacy for greater resources can be viewed as a passive acceptance of the status quo.

Some observers believe that FSR scientists do not compete with other research organizations for funding, and are therefore less competitive than scientists who regularly vie for grants and industrial contracts. Although this perception is partly refuted by the experience in the forestry Competitive Research Grants Program, FSR scientists do largely depend upon annual appropriated funds for support. The tradition of cooperative research with universities and industrial cooperators is seen as promoting cooperation rather than competition. The leadership of FSR has not welcomed the forestry Competitive Research Grants Program, viewing it as a threat to its line item funding (a view with which the university deans disagree). These perceptions, combined with limited funds available to forestry research generally, suggest the need for means to introduce a higher degree of competition within FSR.

Issues to be addressed. It is broadly perceived that the financial resources available to Forest Service Research have been inadequate to support its research programs. Unless FSR redefines its mission more narrowly to fit the expected level of appropriations, it will need to significantly improve its resource competitiveness. If this goal is to be achieved, certain issues must be addressed:

- How can FSR make a more effective case for greater appropriations funding? Can FSR develop a clear vision of its mission and the value of its present and future accomplishments to the nation's interest? Should FSR raise its sights and develop a case for being the nation's premier natural resources research agency, rather than what it is now perceived to be? How can FSR organize and best utilize the support of potential new allies--other

Federal agencies that use its research and want more; environmental advocacy groups concerned with wildland ecosystems; the national scientific community--along with its traditional consitutuency to substantially enhance its resources competitiveness?

- Does FSR want to increase its resource competitiveness enough to really compete? Should FSR reverse its position disapproving of the forestry Competitive Research Grants Program and, together with the universities, promote growth of that program? If overall funding of forestry research is to be significantly enhanced, does not the entire forestry science community need to work with a united will to promote this goal? Should FSR initiate internal competition among scientists and stations for some portion of its research funds, both to stimulate entrepreneurship and to provide a means of recognizing and rewarding its best scientists, thus promoting scientific competitiveness?

- Should Forest Service Research propose an organizational realignment that would likely improve its visibility and its level of institutional support? What form might this realignment take: separating from the Forest Service to become a sister agency reporting to the Secretary of Agriculture, perhaps renamed "Natural Resources Research Service" as an analogy to ARS? Merging with ARS? Or separating from the USDA to become an agency within the Department of the Interior? If it were realigned, would the agency continue to provide the desired level of research support to the remainder of the Forest Service? If FSR proposed such a realignment, could it marshal the active support of its constituency groups, including forestry societies, university forestry schools and the forest products industry? What would be the receptivity of the USDA and the Congress to such a proposal?

Key Problems Raised During the Course of the Study

Three key problems which have emerged during the course of the study and appear to be behind FSR concerns about its competitive standing and the responsiveness of the research decision system were found to be: (1) lack of resources, (2) lack of consensus on the FSR mission, and (3) an institutional reluctance to change. Although lack of resources was cited most frequently, and especially by those interviewed within the Forest Service, the underlying deficiency of a lack of consensus with respect to what constitutes the Forest Service Research mission was a common thread throughout the course of the study, and identified by senior leadership and by knowledgeable outside observers as a principal concern which merits immediate and serious attention. Institutional reluctance to change was less pronounced in being described directly as such, but continually surfaced through a variety of "symptoms" or institutional practices which mirrored this reluctance. Throughout each of these underlying problem areas, there also runs a theme of

the need for more visible, aggressive leadership within the FSR organization. This was not directed so much at individuals as it was to the need for a shift in attitude and stance that is both symbolic and substantive.

Lack of resources

The lack of adequate resources causes all sorts of problems for the Forest Service in its effort to maintain a viable, high quality research program. Among some of the more prominent effects are: limiting new project initiatives, preventing needed update of facilities and equipment, exacerbating efforts at program change, and reducing the ability to compete--both for outside funding and to attract talented newcomers. A number of Forest Service scientists interviewed cited the inability to upgrade either facilities or equipment in their laboratories as a primary reason for losing potential grants among competitive programs. Others attested to specific instances in which candidates for entry positions opted to take a university position because of better equipped laboratories. Research leaders universally decried the limitations imposed on new project initiatives, and deferring opportunities to enter new areas of technology because of the lack of resources. The mini-case studies described in the Task III report also demonstrated the value of new or additional resources as an important factor in successfully initiating program changes.

Everyone recognizes the range of effects that a lack of resources can have. But, apart from the current situation where the Federal government is attempting to reduce total expenditures, and thereby creating an atmosphere of greater competition for limited resources, why is it that FSR seems to be "behind" a more generally rising curve of research expenditures by Federal agencies?

There is a tendency among Forest Service leadership to attribute this to the general state of funding for natural resources research, which is low compared to other research areas. However, there appears to have grown up within the Forest Service leadership an almost defensive view that the Forest Service does well to avoid reductions in its research budget. Discussions with budget and other senior officials at the Departmental, Office of Management and Budget, and congressional staff levels confirm this relatively "ho-hum" stance, and go further to suggest that the Forest Service needs to make a more aggressive, graphic, and sustained case for forestry research if there is to be any change.

One observer noted, "research in the Forest Service has been looked upon as an appendage." Another suggested, "Forest Service research must start with a good case and then develop the means to obtain political support." Still another noted, ". . . the Administration's case is not adequately presented. . . . there is a need to identify the value of Forest Service research." Finally, one senior observer suggested ". . . much of the inability of Forest Service research to forge ahead is internal. . . . research is not well supported by the general leadership of the Forest Service. . . . this, then, is reflected at the Secretarial level where there is little or no visibility of Forest Service Research."

With inadequate institutional support at the Forest Service level, it is virtually assured that little will be done to resurrect budget levels as the decision process moves up the budget ladder to the point that it comes before congressional Appropriations Committees. This is particularly true in the case of the Forest Service which is a somewhat different and separate entity within the Department of Agriculture, since it does not easily "fit" into Agriculture's other primary concerns. Indeed, one outside observer noted, "The Forest Service is not a mainline concern of the Secretary."

The study team believes that a major factor in what appears to be the inability of the Forest Service to make a stronger case for its research activities must stem from the lack of agreement on exactly what constitutes the research mission of the Forest Service. This will be discussed in greater detail below; however, it is extremely difficult to provide substantial and aggressive justification if there is not a clear focus attached thereto. As one congressional staffer noted, "the Committee does not often see the 'whole' of forestry research and what that impact might be."

Another factor which detracts from the ability to "sell" a research program, is the relative lack of cohesiveness which can result from substantial local autonomy or the decentralization of decision making in terms of what constitutes the total research package. To the extent that this package lacks substantial cohesion, it makes the effort to convince others of its necessity considerably more difficult. This does not mean that local needs should go unattended. However, it does mean that special efforts have to be made to demonstrate the important relationships of local activity to overall central program requirements in a way that is convincing and does not simply represent "passing the money out to the Research Stations."

Finally, there is the factor of what a number of observers inside the Forest Service and outside have characterized as declining science leadership. To the extent that this is perceived to be true in the budget process, and this may be either symbolic or substantive, it clearly will have a negative effect on the ability to attract additional resources. Research leaders have voiced the concern that basic research is slowly being deemphasized, and the reservoir of such research is being drained. Some of the more critical outside observers see the Forest Service as losing its standing as a top science group, particularly with respect to basic research, because they perceive that leadership positions are not being filled by persons of recognized standing in the scientific community. Additionally, they believe that Forest Service research has lost its "visibility" in the broader science community, and especially at the Departmental level in the Department of Agriculture. [illegible] Anecdotal evidence confirms the concerns of many research leaders (both inside and outside the Forest Service) that its "visibility" is essentially weak or non-existent outside the forestry community and those agencies with which the Forest Service is an active cooperator.

Lack of consensus on the Forest Service Research mission

The study team continually probed throughout its interviews for a clear statement of mission for research in the Forest Service. The variety of answers confirmed the belief, supported by outside observers, that such a mission has not recently been clearly stated in terms that permit appropriate focus. Obviously, if one makes a mission statement broad enough to be almost universally inclusive, one can achieve consensus, but it does not permit the purpose of such a mission statement to be fulfilled: namely, to provide clear and achievable goals. One Forest Service research leader observed, "Forest Service Research is indefinite in terms of goals--where they want to go, and this tends to be communicated to others." A senior official, outside the Department, put it more directly, "No one has ever defined what the basic mission of Forest Service Research is."

The study team is of a firm belief that a first order of priority for the FSR organization is to develop a consensus on a relatively succinct mission statement. This present deficiency has all sorts of ramifications including: it obscures focus in the important process of priority setting; it undercuts promoting a "good case" for additional resources; and, it dilutes efforts at scientific outreach.

The study team has not probed the variety of reasons as to why this lack of consensus has come about. Typically, it is not a process which took place over a few years, but one which has gradually occurred. However, achieving and retaining a consensus on the research mission will require: (1) more aggressive research leadership, and (2) better communication--both laterally and vertically within the research organization. A senior Department official suggested that the FSR organization needs to communicate better what is needed (i.e., goals). More aggressive leadership will have to be exercised at all levels from research leader to Deputy Chief supporting the central research mission. This should be facilitated by substantially improved and broader communication between the Research Stations and the Washington Office and laterally among Research Stations and among Staff Offices in the Washington Office--both in the Forest Service Research group and among its sister organizations the National Forest System and State and Private Forestry. In the past, the Forest Service has had the reputation for an unusual degree of "openness" of communication among its various elements. This tradition needs to be revived, and there needs to be a more complete sharing of information among the various elements of the research organization.

Institutional reluctance to change

Like other quasi-military organizations, the Forest Service reflects a number of admirable qualities related to this type of organization. Among them are a sense of "belonging" on the part of the members who receive considerable satisfaction from contributing to the organization's goals; the opportunity for virtually life-long career involvement, where paths for achievement and promotion are clear and relatively open on the basis of merit; an organizational ethos which rewards reliability and reasonable

loyalty to the system with reciprocal consideration; and, clearly defined organization, structure, and rules of procedure which are understood and accepted. However, another factor in such organizations typically is a continuing thread of conservatism which treats change with some skepticism, and requires that change be integrated in highly organized fashion. The institutional reluctance to change was characterized by one FSR leader as ". . . talking progressive, but acting conservative."

This reluctance to change has some negative effects when change becomes essential to achieving or retaining vitality of the research program. For example, it can raise serious obstacles when necessity requires the reduction or consolidation of particular research programs. It increases the difficulty of shifting emphasis from one research area to another if there is not consensus among the researchers involved. And, it can delay or undercut new initiatives or priorities through resistance to Washington Office or Research Station direction. One can think of instances in which resistance to particular change may be well-justified or in the best interest of the organization as a whole. However, a variety of elements in the FSR structure tend to result in a general, undifferentiated institutional reluctance to change which inhibits its ability to seek and retain a competitive stature, as well as to be responsive to research needs.

Among factors in the research structure contributing to the reluctance to change are: a relatively high degree of local autonomy of the Research Stations; limited mobility of the FSR community (compared to other elements within the Forest Service); the career-long "tenure" of researchers; the sanctity of the RWU contract for periods of five years or longer; and the panel performance evaluation system. Each of these tends to inhibit, in one fashion or another, the flexibility of the organization's research leadership when confronted with the need for redirection and change.

For example, the panel evaluation system is patterned after the general means by which academic institutions rate faculty for tenure. Typically, judgement is rendered along relatively narrow limits of strict scientific productivity--the number and quality of publications produced--irrespective of other needs or pressures that the organization may have. Consequently, scientists who tend to be responsive to the organization's other needs may be penalized when it comes time for the evaluation of their efforts for promotion or salary purposes. This same system of evaluation becomes a disincentive when a scientist is faced with the need to shift areas of research. Such a shift means that the individual will face a learning period during which his/her contributions are likely to be fewer in building up a reputation within the new area of research. This can easily result in a delay in consideration for promotion or salary increases. Little consideration is given to the needs of the organization in the broader sense through this means of promotion and reward. By the same token it also contributes to limited mobility, as the researcher burrows in to a particular area of research that may be related to one's geographic location.

Admittedly, Forest Service Research is unique among research organizations in that a substantially larger part of its research relates to relatively long-term activities. This puts a premium on staying power and longevity. This need not and should not be sacrificed to swings in the pendulum of

scientific interest. On the other hand, the research community must not fall behind advancing science, nor does it want to lose its sensitivity to the needs of its user clientele--or it will quickly run out of the kind of support which sustains its research efforts.

Areas For Potential Action

The MCRG study team suggests consideration of the following actions as possible options to meet the challenges enumerated above.

There are three principal areas in which action by the Forest Service seems called for: (1) developing a consensus on a more clearly defined Forest Service Research mission, (2) approaches to seeking increased resources, and (3) organizational and administrative realignment. Of these clearly the most important is the definition of the Forest Service Research mission.

Defining the Forest Service Research mission

When persons were asked their perspective of the current mission of Forest Service Research, the answers tended to fall into one of two categories: (1) that the purpose was to support the natural resources community, or (2) that the purpose was primarily to support the National Forest System. There is an intermediate position between these two--that is, the mission can be conceived of as to support forestry in the U.S., both public and private. Each of the three principal candidates will be discussed in terms of practical considerations with respect to their implementation and possible consequences of adopting the particular mission.

The first, perhaps least difficult mission to adopt is that of providing research support to the National Forest System. Such a primary mission would not diminish the value of Forest Service research to users in private forestry, nor in the natural resources community generally. However, the extent to which FSR served these other groups would clearly be secondary to serving the needs of the National Forest System. Such a focus on the National Forest System need not downgrade basic research considerations, because the breadth and extent of National Forest System needs will require a pool of basic research, irrespective of where that is performed. Selecting this mission would permit the FSR organization to concentrate upon a limited number of disciplines, but it would require leaving more general research related to forestry concerns to universities and other organizations. By its very nature it should strengthen the ties between the FSR organization and the National Forest System organization. With the ability to concentrate its resources, it should permit FSR to more effectively protect long term basic research which has been a unique hallmark of Forest Service research. Narrowing its research focus could make FSR less attractive to young scientists; but a more solid support for its scientific base through concentration of resources could be attractive. On the whole, selecting such a mission, limited in comparison to the other alternatives, would restore FSR

to an historic role which could be considered to be the rationale for Forest Service Research at its beginning.

The second alternative mission, supporting public and private forestry in the United States, is only one step removed from putting the primary emphasis upon support of the National Forest System. This mission expands that one by adding forestry concerns principally of the state (with some at the local level) and private interests. The latter constitutes something of a challenge because it is estimated that there are over eight million owners or operators of "private forests." This particular mission probably is closest to the long term historical activities of FSR than is any other. From its beginning, the Forest Service has fostered the close relationship of interests within the forestry community regardless of ownership or location. There are two clear distinctions between the alternative to support primarily the National Forest System and this mission: (1) because one is trying to serve private forestry interests as well, there will be a stronger emphasis in the areas of product harvesting and forest product utilization; and (2) because one is dealing with a substantially increased number of organizations and interests the task of identifying, prioritizing, and integrating research needs will be much greater. Substantially more effort will have to be placed upon sorting out the various roles of Forest Service Research, university research, state and local efforts, and those of private entities. Again, because of the wider clientele to be served, the function of technology transfer will be more complex as will determining the responsibility for this function across the number of actors involved.

The third alternative mission involves the principal responsibility to support the natural resources community. This mission has substantial attraction to it because it is not limiting in terms of scientific activity. It also projects the reality that the Forest Service has been a principal leader in this research, and is acknowledged by most to have filled such a role. On the other hand, it is recognized that this role cannot now be filled without a substantial increase in resources available to the FSR organization. One might reduce the apparent magnitude of such a mission by suggesting that the Forest Service Research organization would provide "leadership" to the natural resources community. However, such a mission would remain somewhat fuzzy, and would have to be further defined in terms of what aspects of natural resources research FSR would be expected to project leadership. FSR can provide leadership to the natural resources community without that being the primary rationale for its existence, but can perform this as a secondary or adjunct function. However, if it were decided that this should be its principal purpose, the FSR organization would have to face the question of significantly larger resources. In addition it would have to extend considerably its outreach and integration activities to the broader scientific community. Research contributions to the natural resources area increasingly are being made from a wider variety of sources outside those organizations which have operational responsibility for natural resources activities. Finally, one would be left with the question as to whether or not, given such a broad mission, the Forest Service would continue to be the proper "home" for this type of research. Although natural resources will remain of primary interest to the Forest Service as an operating organization, dedicating resources for research to serve such a broad

clientele could prove difficult if not impossible within the Forest Service context. Thus one would have to face the real possibility of the removal of the FSR organization to some other location, possibly as a "stand alone" research organization within the USDA or even located elsewhere within the Federal government.

Seeking increased resources

Although the determination of the primary mission of FSR affects the degree to which additional resources for forestry research may be needed, there is a strong consensus that additional resources are needed now and will be in the future. The issue then becomes how such resources can be sought. As comments from interviews with those involved in the budget process reveal, there are a number of actions which clearly are within the means of the Forest Service. These need to be pursued across four levels: (1) within the Forest Service, (2) within the U.S. Department of Agriculture, (3) with the Office of Management and Budget, and (4) with the congressional Appropriations Subcommittees involved.

The first challenge is to make a better case for increased resources within the Forest Service itself. Here the primary need is to document and demonstrate the value of forestry research to the Forest Service. This requires showing how forestry research has paid off in better capability to manage the forestry resources of the National Forest System, how that research has been valuable to private industry served by the Forest Service, to other Federal agencies with natural resources interests, and to other agencies within the Department of Agriculture—all which reflect credit to the Forest Service. From time to time the FSR organization has undertaken studies to reveal the value of particular research. There is little evidence that the results of these studies have been used systematically in the budget justification process—either within the Forest Service or up the line to the Congress. For example, in 1979 a study was undertaken to identify the benefits of Forest Service research. Subsequently, a report was issued in 1980 covering some eighty-one case studies of the use made of research conducted or sponsored by the Forest Service. The study revealed a benefit/cost ratio averaging 50:1, and provided a considerable number of instances which could have been cited as anecdotal evidence of the value of Forest Service research. This type of effort needs to be expanded and used in the budget justification process. In addition, FSR leadership needs to make a more concerted effort to involve officials of the National Forest System, and users from outside of the Forest Service in demonstrating the value of their research, and soliciting the support of these users (both field and Washington Office officials) as part of this process.

Much the same needs to be done in the budget justification process at the Departmental level. At this level it is important to solicit the whole-hearted support of the Chief of the Forest Service. It is especially important at this level to demonstrate the value of Forest Service research to the other agricultural agencies, specifically, the Soil Conservation Service where Forest Service assistance appears to be highly valued. Senior officials involved in the budget process outside of the Forest Service attest

to the relative lack of cohesiveness and analysis in such presentations. One observed that he had not seen much information from the primary users to demonstrate how Forest Service research has contributed to increased productivity. Another indicated that there was little evidence of coordination among somewhat unsettled research priorities. Another noted, that he saw "no evidence of broad support [in the general budget process] for forestry research." All testified to the need for analytically driven analyses combined with political support--in the latter case they mean research users from both within the Forest Service and outside, and especially support by Forest Service leadership. Officials at all levels above the Forest Service who are sympathetic to forestry research attested to the fact that they are in a poor position to make a case for increased resources; the best that they can do is to provide support to avoid reductions or to restore reductions. The case for increased resources must come from the leadership of the Forest Service, supported by users of that research.

The same set of actions will hold true at the OMB level as at the Departmental level. Here, FSR should consider soliciting "testimony" from other Federal agencies where officials are willing to put in a good word for the value of Forest Service research. The MCRG study team ran across several instances where a willingness to provide supporting testimony was expressed. Although such an offer apparently was made to FSR, it was not followed up. Budget review at the OMB level is not an open process--i.e., it is between senior budget staff and top agency or department officials. Therefore, applying such outside testimony will be something of a challenge and will require the assistance of those who participate in this process at the Departmental level.

Finally, discussions with congressional staff members revealed that the kind of information most useful to promoting the case for Forest Service research is the same as that described above. Although analytical support is useful to the Congress, it is important to use specific, graphic examples--anecdotal evidence--of where Forest Service research has resulted in research payoffs. At this level it is even more important that users and cooperators provide firsthand evidence of the value of Forest Service research. This can include written or oral testimony from such cooperators or users as the U.S. Extension Service, the Soil Conservation Service, the Bureau of Land Management, the U.S. Army Corps of Engineers, the National Park Service, the Fish and Wildlife Service, the National Science Foundation, representatives of industry, trade and professional associations, and deans of schools of forestry. There appears to be willingness on the part of officials from many of these organizations to provide assistance in support of Forest Service Research. It appears that these sources of support have been tapped only on a limited basis--primarily universities and industry--and that more organized efforts need to be expended in activating this source of support.

Organizational and administrative realignment

Apart from defining the mission of Forest Service Research and pursuing means to more aggressively seek increased resources, there are a number of

organizational or administrative changes which FSR might pursue to improve its operations generally, reinforce its competitive standing, and facilitate responsiveness to user needs and emerging research opportunities. The MCRG study team recommends the following for consideration by the Forest Service. They range from modest, incremental changes to those that would be more radical. Most are mutually compatible, but several depend upon the nature of the Forest Service mission eventually selected, and the relative willingness to seek increased funding resources. Therefore, these suggestions are not all mutually compatible. Where analogues in other organizations appear to be applicable, those are noted for potential further exploration and consultation by Forest Service Research officials.

Continue to develop and institute mid-range planning. This process is critical to providing rational continuity to the general planning process within the Forest Service, and especially as it relates to research needs. The RPA process is a commendable one, but its long term nature leaves an impossible gap between where it stops and the annual budget process picks up. This gap needs to be filled by a mid-range planning process, a pilot effort of which has already been undertaken and exercised. Such a process requires considerable effort during the first few years to institute, but it is essential if there is to be cohesive and rational planning which manifests itself in systematic (and in the long term) rational budget decisions.

The Forest Service should establish a quality control system for special, large-scale, or interagency research projects. The Forest Service's experience with the National Acid Precipitation Assessment Program and its cooperative research with the Environmental Protection Agency revealed the desirability of a quality control system for such major programs. This is acknowledged both within the FSR leadership and by outside observers. It is particularly important if the Forest Service expects to attract additional outside funding from organizations like the EPA. Furthermore, additional experience with quality control systems can have a beneficial effect in terms of more general quality concerns across Forest Service Research, and through making such quality control systems more useful.

Establish the practice of bi-monthly meetings among counterpart Washington Office Staff Directors. Discussions with staff directors from the Forest Service Research, National Forest System, and State and Private Forestry organizations revealed that there rarely is systematic communication laterally to include the various interests of these three primary organizations at the Washington Office Staff level. Although there appears to be substantial ad hoc consultation, on an as-needed basis, there has been no pattern of regular communications. One FSR observer recalled regular meetings of three staff directors who met to coordinate and exchange information. This was about ten years ago and involved FSR and S&PF staff: Fire Research, Fire and Aviation Management and Cooperative Fire Protection. The staff directors interviewed generally showed interest in the value of regular of meetings to assure appropriate exchange of information and coordination. These meetings need not result in undue time demands if scheduled on a six per year basis.

The Forest Service should undertake wider testing and use of the "SWAT" team concept. The SWAT (Solve With Available Technology) team approach, whereby specialists and researchers are assigned to an ad hoc team to deal with an emerging or emergency problem requiring technological application, is one that deserves assessment, based on wider use. It holds the potential for making technology more widely and immediately available to deal with high priority problems, and provides a vehicle for better integration and understanding among the principal components of the Forest Service in an operational setting. It remains to be determined how widely such ad hoc teams can be used without detrimental interference in ongoing research projects, how such resources should best be managed, and appropriate means for allocating costs, among others.

Consideration should be given to conducting Research/National Forest System interchange meetings on a regular basis. The North Central Forest Experiment Station instituted such cooperative "show and tell" meetings recently. Research Station scientists and National Forest managers meet to exchange information on current research activities and progress, problems encountered by forest managers, and opportunities for cooperation. The meetings involve a single National Forest--often at that location--over a two day period with ample opportunity for one-on-one and informal interaction. It is reported to be highly successful, with an increasing demand for such meetings by NFS personnel. This practice would provide a practical follow-up response to research needs identified in forest plans.

New or consolidated research facilities should be co-located with schools of forestry. This is a practice that appears to be generally followed in recent years by the Forest Service, and one that makes good sense. It should be enunciated as a primary Forest Service policy. Other Federal agencies such as the Agricultural Research Service and the Veterans Administration follow a similar practice in terms of location of their principal research/hospital facilities where that is possible. Making this a clear policy can help provide necessary support for it, may help reduce earmarking, and will require explicit justification where the policy is not followed.

Promotion to senior leadership positions in the Forest Service Research organization should be on the basis of science leadership and management capability. The kind of positions to which this should apply would be the Deputy Chief, Associate Deputy Chief, Station Directors, and Washington Office Staff Directors. Although this appears to have been the general practice in the recent past, this practice should be reemphasized and reenforced to assure science leadership at the key levels throughout the Forest Service Research organization. Some observers believe that inadequate attention has been given to the need for programmatic vision--i.e., understanding program needs and their inter-relationship in the context of future directions and opportunities. Scientific leadership has very important symbolic value in relations to other agencies, with the broader scientific community, and even within FSR. At the same time, management capability is of at least equal importance.

The panel evaluation system should be modified to include credit for technical and management assistance. In addition there needs to be a more

vigorous enforcement of credit to be given for technology transfer activities. Researchers who are called upon to give technical and management assistance, apart from their regular laboratory research, for the general good of the organization and to meet upper level requirements, should not be penalized because of time away from their primary research projects. Since such assistance is deemed of importance to the organization, appropriate credit should be given for it. Field interviews also reveal that the regulation to include technology transfer as a part of the panel evaluation criteria has failed to be enforced during many panel evaluations. It may prove useful for FSR to reassess the current operation of the panel system, and to determine whether or not it continues to serve the best interests of the organization in its current form.

The Forest Service headquarters organization should provide improved assistance to the Research Stations in support of minority hiring goals imposed by headquarters. The Research Stations are not receiving sufficient assistance from the Forest Service headquarters to meet the kinds of requirements imposed upon them with respect to minority hiring. The pool of minority scientists applicable to Forest Service research is extremely small. Research Stations do not represent a sufficient human resource base from which to make substantial outreach efforts. Some are making significant attempts. They deserve a higher order of support from the Forest Service headquarters in terms of central identification of applicable pools of personnel within the minority community, and outreach efforts to undergraduate schools in the process of encouraging minority students to pursue forestry research careers. Even such efforts are likely to be inadequate because the Forest Service itself does not represent a resource base sufficient to deal with the broader problem. Forest Service leadership needs to campaign for higher order assistance at the Departmental and general government levels.

Annual Forest Service peer/user review of RWUs. Both the quality of research and stronger ties to potential users can be fostered if there is annual review of the status and progress of each RWU. Such a review can be informal on a face-to-face basis if the three to four person review committee is located in an area of the Research Station. Or, it can be on a basis of an annual status report, with the reviewers coordinating by simple teleconference. It may be useful to experiment with having one committee member from outside the Forest Service, such as a peer researcher from a school of forestry. Such annual reviews are common in both Department of Defense and NASA laboratories. There, research projects of substantial size often undergo frequent reviews, such as quarterly, to assure timely progress. Such frequency probably is not useful for most Forest Service research, unless it is related to a large development project or to some time sensitive inter-agency activity.

Provide "step funding" for RWU's. Typically, funding for an RWU may be planned but it is not committed except on a year-by-year basis. The Forest Service should investigate the feasibility of providing greater research management flexibility of its RWU's through the technique of "step funding". This would provide funding for an RWU on a two or three year basis in the following fashion. 100% funding would be provided in the current or upcoming

budget year, followed by two-thirds assured funding for the second year and one-third assured funding for the third year--assuming a three year basis. This would facilitate shifting research emphasis while permitting the more orderly phaseout of the research effort on the original program. There are two obstacles to doing this. The first is whether or not such funding could be provided under the current budget authority of the Forest Service. The second is how long a period of time it would take to institute such a program, recognizing that one could not translate all RWU programs into this type of funding in just two or three years, because of the initial costs. If it could be done within the authority of the Forest Service, such an initiative should be spread out over a five- to ten-year time period. It would provide a substantially greater flexibility in moving both research and financial resources around in a fashion that does not unduly damage ongoing research efforts.

The Forest Service should give stronger support to the Competitive Research Grants Program. Although not always acknowledged by Forest Service leadership, it is apparent that the Forest Service gives only lukewarm, if any, support in the budget process to the forestry Competitive Research Grants Program. Data presented in the Task IV Report [pp. G-14] reveals that the Forest Service does well in this competition--primarily with university researchers. This CSRS-administered program provides a source for basic research support, a means for encouraging greater competitiveness among forestry researchers, as well as an arena for FSR cooperation with university researchers. Although there is some inclination among Forest Service researchers to view the program as one which reduces funds available more directly to the Forest Service for research, there is no substantial evidence that funds "saved" by eliminating this program would necessarily go to the Forest Service. It appears that the Forest Service would have considerably more to gain than to lose by joining with the universities in a more vigorous support of this program.

The Forest Service should test user funding of Forest Service applied research and development. For example, a Forest supervisor, who had funds to support research application to a particular need could go to any Research Station to obtain the needed research and development on a mutually agreeable basis. This might require some setting aside of funds within FSR to be used for this purpose. It is suggested on a test basis to determine whether or not some limited use can improve both the ties and the applicability of research for National Forest System needs. It would have the advantage of bringing researcher and potential user closer together in the determination of what research to undertake. Limited use of this technique is relatively common in American industry to permit operating or production units to have more direct access to research capabilities for specific problem solving activities. An important aspect to be assessed would be what ought to be the source of such "problem-solving" research funds?

Centralize the authority for basic research in the Deputy Chief for Research. With increased opportunities for productive basic research, the FSR faces substantial challenges in providing a sufficient concentration of resources to undertake new areas of fundamental research. Appropriately assisted by his Washington Office staff, the Deputy Chief for Research is

best positioned to survey the basic research needs, generally, of the Forest Service and to be in touch with the most recent developments in universities or other research performers related thereto. This would not diminish the basic research undertaken under the auspices of Research Stations where that was essential to a particular research program or applied research project. However, entry into relatively broad fields of fundamental research not specifically targeted to an applications problem would remain the prerogative, in terms of priority development and funding, of the Deputy Chief for Research.

Examples of this practice can be found in the Agricultural Research Service and in the private sector in General Motors. In General Motors, programs of basic research are limited to its central laboratories. Presumably, this makes results rapidly available to any of the users in their general system and assures both a technical and managerial overview. Although the authority for major basic research programs would be centralized in the Washington Office, the actual conduct would be in the Research Stations. Another consequence of this action would be that such research programs are less likely to be considered a continuing piece of any particular Research Station's "turf", regardless of potential capability elsewhere.

The basic research programs of the Forest Service should be open for competition among the Research Stations. This could be instituted without centralizing the authority for basic research, although it would be much easier to do so under that circumstance. Quite a number of observers of forestry research--both within the Forest Service and outside--believe that FSR would benefit from a stronger degree of competition and that the organization is up to facing that competition. Such competition should be limited initially to competition among Research Stations for particular basic research programs. The Deputy Chief could call for proposals within a given area, have these peer reviewed and rated, awarding research programs to those that appear to be most capable and promise the best program. This is similar to the practice within NASA where major research applications programs related to advancing technology for the space station were put out for "bids" to NASA Field Centers. If this type of internal competition proves feasible, it might be extended on a pilot basis to include universities. The purpose would be to hone the entrepreneurial skills and the competitive capability of Forest Service researchers.

The Deputy Chief for Research should be given line authority over the Forest Service Research organization. This authority should include having the Research Station directors report to the Deputy Chief for Research, rather than formally to the Chief of the Forest Service. Admittedly, this would be a substantial change from the general organization of the Forest Service now where the various Deputy Chiefs essentially act as staff advisors and support to the Chief. Giving the Deputy Chief for Research line authority would provide him with clear decision-making authority over all of the elements which he essentially must influence or command within the Forest Service. The purpose is to strengthen the hand of the Deputy Chief in priority setting for national needs, and to provide a means for assuring greater responsiveness to both opportunities and needs at the national level. At the same time this would tend to fix more clearly responsibility in the

Deputy Chief. This should help sharpen research focus, provide support for making hard decisions on research program trade-offs, and stimulate more systematic review of technological trends and opportunities. Similar systems are in place and used effectively within both the National Park Service and the Agricultural Research Service.

Remove Forest Service Research from the Forest Service to a more congenial research setting or as a "stand alone" research organization. This would be a distinct possibility if it were determined that the primary mission for Forest Service research should be to support the natural resources community. It seems unlikely that the Forest Service would vigorously seek the kind of resources essential to meet this kind of mission. If that mission is of sufficient importance, then the Forest Service Research organization probably would function better as an element of the Agricultural Research Service where it would be among scientific peers and judged on a purely research basis. On the other hand, it would make sense to shift such a research organization totally outside of the Department of Agriculture and to the organization which has the broadest collection of functions relating to natural resources--the Department of the Interior. Another alternative would be for it to act as a stand alone, independent research agency. There is some rationality in the latter because no single agency has responsibility across the natural resource span of interest. For example, agencies having such interests include U.S. Department of Agriculture, the Department of the Interior, the Environmental Protection Agency, the National Oceanic and Atmospheric Administration, and the Department of Health and Human Services. Such a move out of the Forest Service is not a political likelihood, but it is not outside the realm of possibility given reorganization initiatives emanating from the White House over the past two decades.

Concluding Observations

The Forest Service Research organization has an enviable record of achievement in providing research support for the Forest Service as well as to the larger forestry community. Over the years it has acquired a principal leadership role in natural resources research. The Research Improvement Team's concern about the FSR's competitiveness and the responsiveness of the research decision system to need for program change has been, at least partially, confirmed. The record on both concerns is quite positive; but the future outlook is, without change, considerably less sanguine.

The FSR seems to be at or near a watershed in terms of where it should go from here. The status quo is unlikely to be satisfactory to anyone. As noted repeatedly, FSR needs a clear statement of its mission as the basis from which to tackle other key decisions regarding how to approach obtaining needed resources, what organizational modifications are required to support the mission selected, and subsequent administrative or procedural changes. The study team is confident that the Forest Service Research organization has the talent to undertake this series of considerations and decisions within itself, through task forces or working groups, and that such an effort can produce the needed guidance for continuing excellence in forestry research.

AFTERWORD

The Role of Technology Transfer in Forest Service Research

During the conduct of this study, the study team received numerous comments and perceptions relating to technology transfer, the role of Forest Service Research (and others) in promoting transfer, and the relationship of technology transfer to responsiveness to user needs. Although technology transfer had not been identified as a topic for exploration, the study team has both considerable experience and interest in research relating to the process of technology transfer. Thus, data were gathered and some observations directly related to study topics were included in the preliminary reports on Tasks IV and V.

Technology Transfer is a subject of very high importance to Forest Service Research but it cannot be appropriately dealt with until the question of the FSR mission is resolved. Nevertheless, some observations and perceptions will be included here.

A widespread perception is that responsibility for transferring technology within the Forest Service is not sharply focussed. State and Private Forestry has a definite role to play, but S & PF has been reduced in resources and is no longer as closely linked with Forest Service Research as it once was, when it was formally integrated with FSR and often co-located with FSR stations and universities rather than at regional offices. The USDA Extension Service has been involved in transfer of forestry research for 75 years, but relatively few of the Extension staff have experience in forestry research and Extension's major thrust has been organized along commodity lines.

Forest Service Research itself formally recognizes a need for its scientists to conduct technology transfer, notably to NFS and S & PF. However, mixed messages abound. Officially, the panel evaluation system credits FSR scientists for technology transfer, yet there is a widespread belief among FSR scientists that they are not credited, and perhaps penalized, for performing technology transfer at the cost of scientific scholarship. Some FSR scientists enjoy technology transfer but state that if they responded to all requests they could do nothing else. Other scientists reject any transfer role and remain immersed in a world of research and publication—without apparent disfavor by FSR supervisors. Often, technology transfer is viewed as a necessary but arduous interruption to science and a task that does not make the best use of the best minds.

Because NFS, S & PF and other users often depend on others with expertise to locate, translate and adapt technology to their needs, there has been dissatisfaction with the availability of research that answers their very real problems. This is perceived sometimes—but not always—as slow and inadequate responsiveness by FSR.

Once the mission question is resolved, attention should be given by the Forest Service to the questions of: Who should have what responsibility for technology transfer? What organizational realignments and staff additions (or transfers) are desirable? and What incentives or rewards are likely to bring about the optimum technology transfer system?

Appendix A

STUDY PROJECT;
ASSESSMENT OF THE COMPETITIVENESS OF FOREST SERVICE RESEARCH

List of Interviewees

June 1988

LIST OF INTERVIEWEES

Alexander, Robert R.	Leader Multi-Resource Management of Central and Southern Rocky Mountain Forests and Woodlands, Rocky Mountain Forest and Range Experiment Station
Alig, Ralph J.	Project Leader, Southeastern Center for Forest Economics Research, Southeastern Forest Experiment Station, Research Triangle Park, NC
Andrus, Sheila	Research Entomologist, Northeastern Forest Experiment Station, Broomall, PA
Barker, Paul F.	Regional Forester, Pacific Southwest Region, San Francisco, CA
Barnard, Joseph E.	Station Director's Representative, Southeastern Forest Experiment Station, Research Triangle Park, N.C.
Bartuska, Ann M.	Program Leader, Air Pollution Impacts on Southeastern Commercial Forests R & D Program, Southeastern Forest Experiment Station, Research Triangle Park, N.C.
Bay, Roger R.	Station Director, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA.
Beasley, Lamar	Deputy Chief, National Forest System, Washington, D.C.; subsequently Station Director, Southeastern Forest Experiment Station, Asheville, N.C.
Beck, Donald E.	Project Leader for Stand Development, Composition and Growth of Southern Appalachian Hardwoods, Southeastern Forest Experiment Station Bent Creek facility, Asheville, N.C.
Benton, Raymond O.	Supervisor, Arapaho and Roosevelt National Forests, Fort Collins, CO
Bentley, Orville	Assistant Secretary of Agriculture for Science and Education, Washington, D.C.
Berg, Neil H.	Project Leader of the Snow Hydrology Project, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA
Bey, Calvin	Forest Recreation and Urban Forestry, Forest Environment Research Staff, Forest Service Research, Rosslyn, VA
Biesterfeldt, Robert	Head of Publications and Information Services,

	Southeastern Forest Experiment Station, Asheville, N.C.
Buford, Marilyn	Forest Biometrician, Loblolly Pine Stand Management Project, Southeastern Forest Experiment Station, Charleston, SC
Burns, Denver P.	Station Director, Northeastern Forest Experiment Station, Broomall, PA
Butruille, John F.	Director, Recreation Management, National Forest System, Washington, D.C.
Chang, Ming Tu	Project Leader, Applications of Biotechnology in Forest Pest Management, Northeastern Forest Experiment Station, Delaware, OH
Conard, Susan G.	Project Leader, the Ecology of Chaparral and Associated Ecosystems, Pacific Southwest Forest and Range Experiment Station, Riverside, CA
Cooper, Arthur (Art)	Head of the Department of Forestry, North Carolina State University
Coster, Jack E.	Director, Division of Forestry, West Virginia University
Denecke, Fred	National Program Leader, Forest Land Management, USDA Extension Service, Washington, D.C.
Dennis, John	National Park Service Research, Washington, D.C.
de Steiguer, J. Edward	Project Leader, Forest Pest Impact Methods Project Southeastern Forest Experiment Station
Dorrell, F. A. (Tony)	Staff Director for Cooperative Forestry, State and Private Forestry, Washington, D.C.
Dutrow, George F.	Dean, School of Forestry and Environmental Science, Duke University
Ellwood, Eric L.	Dean, School of Forest Resources, North Carolina State University
Eshita, Steven	Post-doc. Applications of Biotechnology in Forest Pest Management Project, Northeastern Forest Experiment Station, Delaware, OH
Fedikew, John	Associate Director of the Office of Budget and Program Analysis (Renewable Resources and Special Studies), USDA, Washington, D.C.
Fisher, Richard F.	Head of the Forest Resources Department, Utah

	State University
Fitzgerald, Richard	NFS/Timber Management Staff, Washington, D.C.
Foulger, Albert N.	Assistant Station Director for Research, Northeastern Forest Experiment Station, Delaware, OH
Fox, Douglas G.	Project Leader, Atmospheric Deposition, Rocky Mountain Forest and Range Experiment Station
Geron, Chris	Biometrician in the Forest Pest Impact Methods Project, Southeastern Forest Experiment Station, Research Triangle Park, NC
Gordon, John	Dean of the Yale School of Forestry and Environmental Studies
Halverson, Howard G.	Project Leader, Reclamation of Surface-Mined Areas, Northeastern Forest Experiment Station Office, Berea, KY
Harden, Charles H.	Director, Science and Education, Society of American Foresters, Bethesda, MD
Harris, Frank	Deputy Director for Biotic Systems and Resources, National Science Foundation, Washington D.C.
Haverty, Michael	Project Leader, Biology and Control of Insects Adversely Affecting Regeneration and Establishment of Western Forests, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA
Hendee, John	Dean College of Forestry, Wildlife and Range Sciences, University of Idaho
Hertel, Gerald D.	Program Manager, Spruce-Fir Research Cooperative, Northeastern Forest Experiment Station, Broomall, PA
Hessell, David	Director for Timber Management, National Forest System Washington Office Staff, Washington, D.C.
Hosner, John F.	Director of School of Forestry and Wildlife Research, Virginia Polytechnic Institute and State University
Johnson, Kathy	Professional Staff Member, House Appropriations Subcommittee on Interior and Related Agencies, Washington, D.C.
Johnson, Robert	NFS/Timber Management Staff, Washington, D.C.
Johnson, Terry	Forester, Soil Conservation Service, USDA,

	Washington, D.C.
Kinlaw, Claire	(Post-doc) Pacific Southwest Forest and Range Experiment Station, Berkeley, CA
Knauer, Kenneth	Assistant Director, Forest Pest Management, State and Private Forestry, Washington, D.C.
Knighton, Dean	Forest Environmental Research Staff, Watershed Management and Rehabilitation Research, Washington, D.C.
Knowles, Don	Senior Staff Member, Senate Appropriations Subcommittee on Interior and Related Agencies, Washington, D.C.
Krugman, Stanley	Staff Director for Timber Management Research, Forest Service, Washington, D.C.
Kuhlman, Ronald L.	Chief, Division of Resource Sciences, Bureau of Land Management, U.S. Dept. of the Interior, Washington, D.C.
Lanner-Herrera, Carita	Applications of Biotechnology in Forest Pest Management Project, Northeastern Forest Experiment Station, Delaware, OH
Larson, Gerald	Staff Chief, Natural Resources, Science and Education Office of Budget and Program Analysis, USDA, Washington, D.C.
Lee, J. Charles	Head Department of Forest Science, Texas A & M University
LeMaster, Dennis C.	Chairman, Department of Forestry and Range Management, Washington State University
Leonard, George M.	Associate Chief of the Forest Service, Washington, D.C.
Lewis, Darrell	Chief of the Natural Resources Management Branch, Corps of Engineers, U.S. Army, Washington, D.C.
Lewis, Gordon D.	Assistant Station Director for Research Planning and Application, Southeastern Forest Experiment Station, Asheville, N.C.
Lewis, Robert, Jr.	Assistant Director for Planning and Application, Northeastern Forest Experiment Station, Broomall, PA
Lloyd, F. Thomas	Southeastern Forest Experiment Station, Clemson, South Carolina

Loveless, Charles M.	Station Director, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO
Lynch, Ann M.	Pest Impact Assessment Technology Project, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO
Mace, Arnett C.	Director of School of Forest Resources and Conservation, University of Florida
MacCleery, Douglas	Deputy Assistant Secretary for Natural Resources, USDA, Washington, D.C.
McClure, Joe P.	Head of Forest Inventory and Analysis, Southeastern Forest Experiment Station, Asheville, N.C.
McDonald, Stephen	Assistant Station Director, (Research), Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO
McDonald, Mike	Staff Member, Natural Resources, Science and Education, Office of Budget and Program Analysis, USDA, Washington, D.C.
McFadden, Max W.	Program Manager, Gypsy Moth and Eastern Hardwoods Research, Northeastern Forest Experiment Station, Broomall, PA
Mickler, Robert A.	Forest Response Program Quality Assurance Specialist, Northrop Services, Inc., Southeastern Forest Experiment Station, Research Triangle Park, N.C.
Millar, Connie	(Post-doc) Pacific Southwest Forest and Range Experiment Station, Berkeley, CA
Mills, Thomas J.	Staff Assistant for Budgets, Forest Service Research, Washington, D.C.
Moeller, George H.	Staff Assistant, Forest Service Research, [and first study Technical Monitor], Washington, D.C.
Moore, Shirley A.	Assistant Station Director for Administration, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA
Musselman, Robert	Atmospheric Deposition Project, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO
Neal, Dave	(Post-doc) Pacific Southwest Forest and Range Experiment Station, Berkeley, CA
O'Connell, Paul	Deputy Administrator, OGPS, Cooperative State Research Service, USDA, Washington, D.C.

Ohman, John H.	Deputy Chief for Research, Forest Service, Washington, D.C.
Orly, Roxanne	Head of Grants and Agreements, Department of Administration, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA
Osborne, Nancy	Staff Assistant, Office of the Deputy Chief for Research, Forest Service, Washington, D.C.
Osterhaus, Cary	Division of Forestry, Bureau of Land Management, U.S. Dept. of the Interior, Washington, D.C.
Perry, John	Member of the Board on Atmospheric Sciences and Climate, National Academy of Sciences, Washington, D.C.
Peters, John L.	Head of Forest Inventory Analysis and Economics, Northeastern Forest Experiment Station, Broomall, PA
Philpot, Charles W.	Associate Deputy Chief for Research, Forest Service, Washington, D.C.
Powers, Harry R., Jr.	Project Director, Diseases of Southern Pine Plantations and Seed Orchards, Southeastern Forest Experiment Station, Athens, GA
Pye, John	Ecologist, Forest Pest Impact Methods Project, Southeastern Forest Experiment Station, Research Triangle Park, N.C.
Radloff, David	Staff Member of Forest Environmental Research, in charge of acid rain program
Rice, William	Deputy Chief for Administration, U.S. Forest Service, Washington, D.C.
Robertson, F. Dale	Chief of the Forest Service, Washington, D.C.
Romancier, Robert M.	Deputy Director, Northeastern Forest Experiment Station, Broomall, PA
Rosen, Howard N.	General Research Engineer, Forest Products and Harvesting Research Staff, Forest Service
Ross, Eldon	Associate Deputy Chief for Research, Forest Service, Washington, D.C.
Roussopoulos, Peter J.	Fire Sciences Staff [and second study Technical Monitor], Forest Service Research, Washington, D.C.

Ruark, Gregory A.	Forest Soil Productivity Unit, Southeastern Forest Experiment Station, Research Triangle Park, N.C.
Rumburg, Charles (Bud)	Deputy Administrator, Natural Resources Food and Social Sciences, Cooperative State Research Service, USDA, Washington, D.C.
Sampson, Neil	Executive Vice President, American Forestry Association, Washington, D.C.
Satterfield, Steven	Natural Resources, Office of Management & Budget, Washington, D.C.
Saucier, Joseph R.	Project Leader of the Utilization of Southern Timber Project, Southeastern Forest Experiment Station, Athens, Georgia
Sesco, Jerry A.	Deputy Chief For Research, Forest Service, Washington, D.C.
Sirmon, Jeff M.	Deputy Chief for Programs and Legislation, Forest Service, Washington, D.C.
Skok, Richard A.	Dean of College of Forestry, University of Minnesota
Slocum, Robert	American Forest Council, Washington, D.C.
Smith, Richard N.	Regional Director, Region 8 (Research and Development), Fish and Wildlife Service, U.S. Department of the Interior, Washington, D.C.
Smythe, Richard V.	Staff Director, Forest Environment Research Staff, Forest Service, Rosslyn, VA
Sommers, William T.	Staff Director, Forest Fire and Atmospheric Sciences Research Staff, Forest Service, Rosslyn, VA
Stewart, Ronald E.	Assistant Station Director for Northern California Research, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA
Stoltenberg, Carl H.	Dean, College of Forestry, Oregon State University
Swift, Lloyd W., Jr.	Southeastern Forest Experiment Station, Coweeta Hydrologic Laboratory, Otto, N.C.
Taras, Michael A.	Head, Department of Forestry, Clemson University
Thatcher, Robert C.	Assistant Station Director for Research Programs, in Florida-Georgia, Southeastern Forest Experiment Station, Asheville, N.C.

Thorud, David B.	Dean, College of Forest Resources, University of Washington
Tombaugh, Larry	Chairman, Department of Forestry, Michigan State University
Unger, David G.	Associate Deputy Chief, National Forest System, Washington, D.C.
Van Sickle, Charles C.	Assistant Station Director for Research Programs in Virginia-Carolinas, Southeastern Forest Experiment Station, Asheville, N.C.
Vose, Jim	Post-doc, Southeastern Forest Experiment Station, Coweeta Hydrologic Laboratory, Otto, N.C.
Wagner, Alan J.	Head of Personnel Management Southeastern Forest Experiment Station, Asheville, N.C.
Waide, Jack B.	Southeastern Forest Experiment Station, Coweeta Hydrologic Laboratory, Otto, N.C.
Waldrop, Tom	Post-doc, Southeastern Forest Experiment Station, Clemson, South Carolina
Wear, David	Research Forester (Economics Branch), Southeastern Forest Experiment Station, Research Triangle Park, NC
Wells, Carol G.	Forest Soil Productivity Unit, Southeastern Forest Experiment Station, Research Triangle Park, N.C.
Welsh, Gerald B.	Research Coordinator, Soil Conservation Service, USDA, Washington, D.C.
West, Allan J.	Deputy Chief, State and Private Forestry, Washington, D.C.
Wicker, Ed F.	Assistant Station Director (Research), Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO
Yates, Harry O., III	Project Leader of Biology Ecology and Management of Cone and Seed Insects of Southern Forest Trees Project, Southeastern Forest Experiment Station, Athens, GA
Haynes, Wayne	Director of Forest Research, International Paper Company, Savannah, GA
Montrey, Hank	Deputy Director, Forest Products Laboratory, Madison, WI
Johnson, Norman E.	Vice President, Research and Development, Weyerhaeuser Company, Tacoma, WA

Appendix B

STUDY PROJECT:
ASSESSMENT OF THE COMPETITIVENESS OF FOREST SERVICE RESEARCH

Effectiveness of Forest Service Research Program

Change Mechanisms: Three Case Vignettes

June 1988

Effectiveness of Forest Service Research
Program Change Mechanisms: Three Case Vignettes

In conjunction with Task III, "Effectiveness of Program Change Mechanisms In Forest Service Research," The MCRG study team collected background information for three mini-cases or vignettes of FSR program change. Three such instances were selected in consultation with the COTR: (1) The Acid Rain Program, (2) The Reprogramming of Watershed Research, and (3) Fire Research Reorganization. The purpose has been to give a substantive, contextual basis--by way of these "thumb-nail" sketches--to better understand how the research management system (including the people) deals with change.

Information for these vignettes was obtained through interviews with responsible staff officials in the Washington Office and with selected participants at the Experiment Stations visited, as well as through reports and other written material supplied by those interviewed. Interpretation is solely that of the MCRG study team.

The three cases differ substantially in terms of the process by which change was met. In the case of the Acid Rain Program external events, primarily congressional action, followed by a national program, imposed the need to act. Notwithstanding some field-level interest in the subject, acid rain did not rate high on the FSR agenda until the establishment of the National Acid Precipitation Assessment Program, followed by increased funding from congressional and other Federal agency sources. The FSR response was to create an ad hoc structure for this program, providing for interagency and system-wide coordination via a program manager in the Washington Office and assigning considerable responsibility for field coordination of sub tasks to specifically identified persons at field locations. This departs somewhat from the typical lines of authority in favor of a matrix management project style. However, the consensus is that it has worked well, accomplishing the dual purposes of facilitating broad inter and intra-agency coordination, as part of a larger program, and permitted reasonable latitude for day-to-day management in the field.

The Reprogramming of Watershed Research has been linked closely to the Acid Rain Program, although it followed a pattern of more traditional change within the FSR system. The genesis of change was already well underway among field researchers, responding to local needs, before the shifts became formal at the headquarters level. Change was gradual, aided by the rising concern of acid rain and related environmental concerns. Here, the system adjusted to change quite easily.

The Fire Research Reorganization case presents quite a different perspective. The effort in analysis, planning, and preparation which went into this was substantial. A diverse, widely scattered series of research activities were consolidated and re-cast to achieve a more rational, hopefully more defensible research program. Many interests were affected, and the process deviated from traditional Forest Service practice of extensive, open involvement. Basic goals were achieved, but not without noticeable pain and some scars that went deeper than anticipated.

Only three short cases cannot represent the whole FSR system. But they do reveal the ability to adapt to change successfully, though not always without disruption or some dissatisfaction. They do reflect some attitudes of insularity and reluctance to change in the field, along with the need for headquarters staff to be sensitive to changing needs and opportunities. Sometimes the latter is accomplished at some risk to the particular leaders who take the initiative.

. **Fire Research Reorganization**

The leadership for fire research in Washington recognized that the general program was suffering from inadequate resources, a geographically scattered program, and what was perceived to be the loss of critical mass to sustain quality research. The problem stemmed from a declining budget for fire research which had reached a high of 12 percent of the FSR budget in 1973 and gradually was reduced to 6 percent by 1985. The objective in developing and carrying out a plan for reorganization of this research activity was to undertake a "one-shot" reorganization that would consolidate research sites and provide a more rational program overall. In the process of studying the problem and possible alternatives, the Washington Office staff conducted a detailed analysis on a unit-by-unit, problem-by-problem basis which included substantial consultation with users of the research. The reorganization plan called for the closing of several fire research activities, the transfer of scientists and support staff (e.g. technicians) to other locations, and the movement of some equipment. Stations where fire research was to be closed out or substantially reduced were: Bend, Oregon; East Lansing, Michigan; Fairbanks, Alaska; Flagstaff, Arizona; and Macon, Georgia. Transfers of research were to be made to Missoula, Montana and Riverside, California.

Based on previous experience there was concern that the traditional style of operating whereby each research unit would be fully consulted and involved in the planning of substantial research changes could not be followed. It was believed that the affected activities would generate political support that would thwart the reduction of fire research at particular locations or the transfer of individuals and equipment. This proved to be true in several instances, although the basic program change was accomplished and the consolidations made. Congressional pressure prevented the transfer of the fire research activities originally scheduled for Bend, Oregon and East Lansing, Michigan. In this process the Station Directors and Assistant Directors for Research were consulted by the Washington Office. Reorganization plans were developed in Washington and passed to the field for implementation. The specific research scientists and technicians involved were not notified until the announcement from Washington of the full reorganization was made.

There were some important costs in the accomplishment of this reorganization: (1) there was the anticipated disruption in research at the affected field stations from the time of the announcement through the first year or more after the consolidations occurred; (2) two valuable scientists were lost to the Forest Service who refused to make the physical move, and took employment elsewhere; and, (3) the reorganization appeared to violate

what had been a Forest Service practice of "looking after their own," through prior consultation and involvement in arrangements. One observer noted, "The Forest Service is a family organization and we usually treat people well. This was an exception." The planning did include concern regarding the protection of individual's job tenure. However, it did not anticipate the strong resistance to moving from one location to another by the scientists or technical support staff.

Although there was the loss of several scientists, including some with expertise that proved difficult to replace, the other side of that coin was that there were research slots opened which provided the opportunity to bring in new people to participate in fire research. In retrospect, some researchers (not involved in the actual transfers) acknowledge that the fire research program was strengthened.

This case demonstrates two important considerations regarding responsiveness to the need for program change. The first is the need for research management to make difficult and sometimes unattractive decisions if one is to retain a quality scientific program. Second, it reveals the strong tendency on the part of the research organization to resist change strongly. Indeed, it was recognition of this stance that encouraged the Washington Office staff director to bypass the more traditional consultative approach to change in order to avoid undercutting what he saw as a necessary change. In the process, there were several outcomes which proved more negative than anticipated, including some loss of trust in the traditional paternalism of the Forest Service.

Acid Rain Program

The Acid Precipitation Act of 1980 established a task force to oversee and coordinate the National Acid Precipitation Assessment Program (NAPAP). The Forest Service became the lead agency for the Department of Agriculture in this effort, and received new program funds directly as well as funds transferred from the Environmental Protection Agency (EPA). This is an instance where a major national policy thrust on the part of Congress and the Administration provided an opportunity and new resources to undertake research related to forestry concerns. It represents a combination of the extension of then current research, some refocussing of research, and substantial expansion through new programs. Although the NAPAP was established by the 1980 legislation, it was not until 1982 that there began to be a coordinated research program with more clearly identified funding. By 1984 the Forest Service recognized the acid rain (or atmospheric deposition) program as a major research thrust. It received top level attention, a joint program with EPA was worked out, and new funds were sought more aggressively. Planning for this joint program brought together a wide range of researchers to identify scientific needs as well as societal and political demands.

In order to meet a rather substantial infusion of new financing, the Forest Service established at the national level a program management focus with a program management matrix structure whereby various projects could be undertaken at a number of Forest Experiment Stations with grants and contracts related to those specific assignments managed by the respective Experiment Stations. At the outset, the Forest Service tended to follow its

traditional pattern whereby funds for this effort went to FSR scientists first, with remaining funds used to supplement FSR through grants or contracts to universities and other cooperators. During 1984 and 1985 this became more cohesive under coordination from the Washington Office. Experiment stations would receive guidelines and objectives (toward which they had contributed), and specific projects would be put up for competition whereby those "bidding" would propose a research approach and methodology. The "winning" station would be assigned the project--which might include grant or contract activity with other cooperators.

In one respect, responsiveness to this type of program change was facilitated by several important elements: first, it was a national program initiative cutting across government agency lines and strongly supported by both the Congress and the Administration. Coordination at the Washington level was essential. Second, it brought with it an infusion of new money which provided opportunities for forestry-related research that had not previously been available. And FSR did not have sufficient inhouse research capability to meet the needs. Third, the Washington Office tapped FSR field talent on the planning and worked closely with the Research Stations involved.

However, this did not reduce a number of substantial program implementation challenges. (It's important to recognize that these are implementation challenges, and not research decision challenges). One of those challenges was accommodating a non "forestry" agency such as EPA. EPA being a regulatory agency, not a traditional scientific organization, provided the Forest Service a new series of challenges in communication, understanding, and coordination.

Another challenge was the imposition of a detailed preplanning process that promoted standardization of research methodology, rather than the experimentation familiar to Forest Service scientists, in order to meet stringent schedule goals. This early standardization of method, while necessary to meet a program schedule, was viewed by some as preempting experimentation that could determine the optimum research method, and lead to superior scientific results.

A third challenge was the relatively stringent quality control requirements placed upon the research program by EPA. This was to meet the world of the regulatory agency--especially the requirement that this data be able to be well defended in the judicial arena where nearly any substantial environmental question migrated sooner or later. In this instance, a special quality control function was established by the EPA to monitor research and to assure that research data and results had a systems reliability that could meet EPA's needs. This type of "quality control" was considerably different from that to which Forest Service researchers had been accustomed--i.e. the technical peer review and professional journal refereeing which usually suffices for the scientific community. This particular quality control element was not completely palatable to Forest Service researchers participating in the program. It became apparent to the research management of the Service that the opportunity to participate in this highly attractive research hinged upon meeting EPA's needs, and that stance apparently facilitated acceptance.

This program demonstrates both the need for Washington Office coordination of a national, interagency effort, and the value of substantial flexibility in the Experiment Stations to deal with day-to-day management and research challenges of particular research efforts. In retrospect some have acknowledged that this type of quality control provided a useful experience to Forest Service researchers that would be valuable in the future, despite being a considerably different approach than what they were used to. In this case change was sweetened by new sources of research support and the opportunities to undertake new research initiatives.

Reprogramming of Watershed Research

The Forest Service decision to actively participate in the national acid rain assessment program caused a reshuffling in the agency's watershed research program. This program was affected because prior to 1980 most of the research within FSR that could be related to acid rain was in watershed research. The program had been involved in water quality issues since the late 1960s. Since 1980 more than 20 percent of the watershed research dollars has been reprogrammed toward the acid rain effort. Further, because of widespread support in acid rain research, the watershed research budget has remained essentially stable at approximately 12.6 million dollars per year (in 1987 dollars).

During reprogramming there was some reluctance among field activities to make rapid program shifts for several reasons. Among them have been a concern that the acid rain emphasis is a passing fad of marginal utility to the National Forest System, and the peer review system used for the National program has been something of an intrusion to the typical research programming and accountability system used within FSR. On the other hand, a number of research leaders within FSR welcomed the opportunity for acid rain funding which was viewed as an opportunity to make use of current skills and scientific talent which otherwise might not be protected during a period of relative downsizing of the overall FSR budget. In addition, others saw the opportunity to build on FSR strengths in the watershed program which had a history of meeting long term objectives in data collection and analysis, not otherwise available in United States.

Thus there gradually occurred an incremental "reorganization" in the watershed research area—primarily resulting from the convergence of several factors: (1) political support for a national research program on acid rain, (2) a decade long emergence of local or regional concerns on a spectrum of water quality problems, such as those resulting from logging and other forest management activities, and (3) a desire by Station Directors to protect their scientific staff in the face of declining overall budgets. The net result was a gradual shifting of focus by several RWU's, with the change being generated both through initiative from the field as well as a new aggregate focus at the Washington Office level. The shift was gradual and contributed to increased emphasis upon water quality concerns and away from water quantity concerns.

Acid rain research has been centered upon the north central and eastern research stations (North Central, Northeastern and Southeastern Research Stations), while there has been a substantially lesser impact in the western part of the United States. However, emphasis upon water quality in the West

has been driven by other local interests. An example of this is the initiative taken by the Pacific Southwest Research Station in cooperation with the State of California in a program on Cumulative Watershed Effects. The concern began with the impact of lumbering (primarily siltation) on water quality. However, concerns of water quality throughout California centering upon possible chemical pollution and related activities resulted in joint efforts which attracted support from the national level.

This Reprogramming of Watershed Research was relatively successful. That success probably rested on such factors as: (1) the availability of funding for new work while providing assistance to ongoing parallel efforts; (2) the fact that change was not abrupt, but incremental, and researchers tended to be led toward opportunities for research funding that neither dislocated people nor required rapid refocusing of research efforts; (3) needed change was evident to the more perceptive researchers involved, coupled with a willingness of others to follow their lead; and, (4) a general acceptance of national priorities in lieu of local priorities.

Appendix C

STUDY PROJECT:
ASSESSMENT OF THE COMPETITIVENESS
OF FOREST SERVICE RESEARCH

Study Bibliography

June 1988

STUDY BIBLIOGRAPHY

American Forest Council. Forest Industry--Sponsored Research Cooperatives at U.S. Forestry Schools: Survey Results. October 1987.

American Forest Council. University-Based Forest Biotechnology Research Programs: Survey Results. October 1987.

Brazzel, John M. "Evaluation of Agricultural Research: Program Evaluation Methods and Approaches." Proceedings of a Symposium: Analysis of Returns to Agricultural and Related Research in the North Central Region. Minneapolis: April 1981.

Brazzel, Michael, and Michael, John A. "An Assessment of the Extension Service's New Models Program in Its First Year, Fiscal Year 1983." December 20, 1983.

Brenneman, Judy, and Blinn, Tawny, eds. Long-Term Ecological Research in the United States: A Network of Research Sites, 1987. 4th Edition (Revised). Corvallis: Oregon State University, 1987.

Briefing Book for 1988 Congressional Budget Hearings.

Briefing Paper on Developing S & PF Technology Transfer at the FPL.

Buckman, Robert. "Summary: Reflections on Forestry Research Evaluations." Forestry Research Evaluation: Current Progress, Future Directions. Workshop, August 20-21, 1984.

Congress of the United States, House Committee on Appropriations. Hearings, Department of the Interior, 100th Cong., 1st Sess., 1987.

Congress of the United States, Office of Technology Assessment. A Review of U.S. Competitiveness in Agricultural Trade: A Technical Memorandum. October 1986.

Congress of the United States, Office of Technology Assessment. Technology, Public Policy, and the Changing Structure of American Agriculture: A Special Report for the 1985 Farm Bill. 1985.

Congressional Forestry Caucus. Task Force 2000, Papers. 1987

Cyert, Richard M., and Mowery, David C. Technology and Employment: Innovations and Growth in the U.S. Economy. Washington, DC: National Academy Press, 1987.

Dennis, John G. "Building a Science Program for the National Park System." The George Wright Forum. 4:3, 1985, 12-22.

Driver, B.L. and Kock, Niels Elers. "Conditions Which Nurture the Application of Forest Recreation Research Results." nd.

Fedkiw, John. "The Role of Research and Resource Productivity Perceptions in Federal Resource Allocation Decisions." 1981 SAF Proceedings. 1982.

Field, Richard C. Development of a Procedure Involving Research Scientists and National Forest Interdisciplinary Teams to Evaluate the Research Needs Identified in National Forest Planning. Athens, Georgia: July 10, 1985.

Gaskin, Julia, W., Douglass, James E., and Swank, Wayne T., compilers. Annotated Bibliography of Publications on Watershed Management and Ecological Studies At Coweeta Hydrologic Laboratory, 1934-1984. USDA, Forest Service: October 1983.

Giese, Ronald L. "Forestry Research: An Imperiled System." Staff Paper Series Number 30. Madison: University of Wisconsin, Department of Forestry, June 8, 1987.

Harvard Business Review. R & D Management Series (reprints). 1957.

International Union of Forestry Research Organizations. Proceedings of Working Party S4.05-05: Valuation of Forestry Research; Forestry Science Serving Society. XVIII IUFRO World Congress: September 12, 1986.

Kaufman, Herbert. The Forest Ranger: A Study in Administrative Behavior. Baltimore: The Johns Hopkins Press, 1967.

Landau, Herbert B., Maddock, Jerome T., and Costello, Joseph G. The Information Transfer Model Approach to Defining Information Users and Outputs. [photocopy, nd.]

Lingwood, David A. "A Model of Research Dissemination and Utilization: Questions for the Dental Research System." Prepared for the Behavorial Science Colloquium, American Dental Association, December 5, 1973.

Lingwood, David A. "Analyzing your Knowledge Flow System." Paper presented at CRUSK, October 23, 1974, Estes Park, Colorado.

Mobley, Hugh E., et al. A Guide for Prescribed Fires in Southern Forests. USDA, Forest Service: May 1977.

Moeller, George M. "Trend Analysis, USDA Forest Service Research Program, 1978-1986." October 7, 1986.

Moses, Phyllis B., and Hess, Charles E. "Getting Biotech into the Field." Issues in Science and Technology. Fall 1987, 35-41.

Muth, Robert M., and Hendee, John C. "Technology Transfer and Human Behavior." Journal of Forestry. March 1980: 141-144.

National Academy of Sciences, National Research Council. A Report by the Advisory Committee to the National Park Service on Research. August 1963.

National Acid Precipitation Assessment Program. Annual Report, 1986.

National Acid Precipitation Assessment Program. NAPAP Operating Research Plan: 1986-1988.

National Agriculture Research and Extension Users Advisory Board. Appraisal of the Proposed 1988 Budget for Food and Agricultural Sciences: Report to the President and Congress. February 20, 1987.

National Association of Professional Forestry Schools and Colleges, and Cooperative State Research Service, USDA. Progress and Promise: A Commemoration of the 25th Anniversary of the McIntire-Stennis Cooperative Forestry Research Program, 1962-1987. August 1986.

National Association of Professional Forestry Schools and Colleges, and Cooperative State Research Service, USDA. A Quarter Century of Progress: The McIntire-Stennis Cooperative Forestry Research Program, 1962-1987. August 1986.

National Association of Professional Forestry Schools and Colleges and Cooperative State Research Service, USDA. University-based Forestry Research: Unlocking the Future. February 1985.

National Pork Producers Council. 1987 Research Investment Report. 1987.

National Research Council, Committee on Biosciences, Research in Agriculture, Board on Agriculture. New Directions for Biosciences Research in Agriculture: High-Reward Opportunities. 1985.

National Research Council, Committee on a National Strategy for Biotechnology in Agriculture, Board on Agriculture. Agricultural Biotechnology: Strategies for National Competitiveness. Washington, DC: National Academy Press, 1987.

National Science Foundation. Federal Funds for Research and Development, Fiscal Years 1982, 1983, and 1984. Surveys of Science Resource Series: 1983.

National Science Foundation. Federal Funds for Research and Development, Fiscal Years 1986, 1987, and 1988. Surveys of Science Resource Series: 1987.

National Science Foundation. Federal R&D Funding by Budget Function, Fiscal Years 1985-87. Division of Science Resources Studies: March 1986.

National Science Foundation. Federal R&D Funding by Budget Function, Fiscal Years 1986-88. Division of Science Resources Studies: March 1987.

National Science Foundation. Science and Engineering Personnel: A National Overview. Surveys of Science Resources Series: December 1984.

New Technology Week. Vol. 1, No. 2, June 8, 1987.

O'Connell, Paul F. "Forestry Research Challenges for the 90's" (draft). USDA, Cooperative State Research Service: October 14, 1987.

O'Connell, Paul F. "Commercializing Promising Technologies" (draft). USDA, Cooperative State Research Service: March 2, 1988.

O'Laughlin, Jay. The Proportion of Forest Service Research Classified as Techlnology Sustaining. College Station: Texas A&M University, October 1985.

Pearce, Richard B. "Caspar Creek: Discovering how Watersheds Respond to Logging." Forestry Research West, USDA, Forest Service, August 1987, 10-15.

The Pinchot Institute for Conservation Studies. Fostering and Managing Innovation in the Forest Service. USDA, Forest Service: April 1983.

Prosser, Norville S. "Summary Comments." Forest Service Southern Research Review. February 1988.

Rogers, David L., Bartlett, E.T., Dyer, A.A., and Hughes, Jay M. Research and Education Systems for Renewable Resources: A Study of Public and Private Sector Research and Education for Private Forestland Management, Wood Utilization and Rangeland Management. Volume 1: Case Studies of 11 States; Volume 2: Results of State and County-Level Interviews; Volume 3: The National System--Public Agencies and Private Organizations. Fort Collins: CSU, May 1986. Volume IV: Synthesis and Options. (Draft) November 1987

Shafer, Elwood L. "Some Thoughts on the Application of New Technology to Resource Management Needs." nd.

Shafer, E.L. and Moeller, G.M. "Evaluation of Innovations from Forest Service Research." USDA, Forest Service: nd.

Society of American Foresters. SAF Manual. January 1987.

Southern Industrial Forestry Research Council. Priority Research from Forest Industry View. Report No. 4.

Swank, W.F. and Crossley, D.A., Jr. Ecological Studies. Volume 66: Forest Hydrology and Ecology at Coweeta. New York: Spinger Verlag NY, Inc., 1988.

Taylor, Calvin W. and Barron, Frank. Scientific Creativity: its Recognition and Development. NY: John Wiley & Sons, 1963.

Thorud, David B. Futures in Forestry Research--What Role the Nation's Forestry Schools? Syracuse: State University of New York Facualty of Forestry Misc. Pub. No. 11, March 18, 1986.

Title 1400 - Controls, Chapter 1470. Research Reviews.

USDA. Agricultural Research for a Better Tomorrow: Commemorating the Hatch Act Centennial, 1887-1987. 1987.

USDA. Future Challenges in Renewable Natural Resources: Proceeding of a National Workshop, January 22-25, 1979, Rosslyn, Virginia. Miscellaneous Publication No. 1376: September 1979.

USDA. 1987 Yearbook of Agriculture: Our American Land. 1987.

USDA. 1987 Fact Book of U.S. Agriculture. July 1987.

USDA and Land Grant Universities Cooperating. Popular Reporting of Agricultural Science: Strategies for Improvement. October 22-26, 1979.

USDA, ARS. Agriculture Research Service Program Plan: 6-year Implementation Plan, 1986-1992. September 1985.

USDA, ARS. Agriculture Research Service Program Plans. Miscellaneous Publication No. 1429: January 1983.

USDA, Cooperative State Research Service. Cooperative Forestry Research Advisory Council 1985 Annual Report. 1985.

USDA, Extension Service. Cooperative Extension and the Generation, Transfer and Use of Technology and Practice: A New Conceptual Model. November 15, 1987.

USDA, Extension Service. Technology Transfer in USDA. April 1987.

USDA. Forest Service Manual. Series 4000--Research.

USDA, Forest Service. "Appendix I: Research Program Development." Final Environmental Impact Statement, 1985-2030: Resources Planning Act Program. FS-403: October 1986.

USDA, Forest Service. "Basic Research in Forest Biology." Panel Report to Deputy Chief for Research. November 17-19, 1987.

USDA, Forest Service. Coweeta Hydrologic Laboratory: A Guide to the Research Program. October 1984.

USDA, Forest Service. Criteria for Deciding About Forestry Research Programs. General Technical Report WO-29: July 1981.

USDA, Forest Service. Data, Memoranda, on the Forestry Competitive Research Grants Program. 1985-1987.

USDA, Forest Service. Evaluating Research Needs Identified in Land and Resource Management Plans for National Forests in the Southern Region. October 1, 1987. Summary of the Evaluation of Research Needs Identified in Land and Resource Management Plans for National Forests in the Southern Region. January 11, 1988.

USDA, Forest Service. "Evaluating Research Needs Identified in Land and Resource Management Plans." Report of June 16-18, 1986.

USDA, Forest Service. Final Environmental Impact Statement: 1985-2030 Resources Planning Act Program. October 1986.

USDA, Forest Service. Forestry Research Evaluation: Current Progress, Future Directions. General Technical Report NC-104: September 2, 1985.

USDA, Forest Service. A Guide to Help Package Research for Applications. November 1985.

USDA, Forest Service. Making Our Forests and Rangaelands More Productive: 1985 Research Accomplishments. General Technical Report WO-52,: September 1986.

USDA, Forest Service. Memorandum about CRUSK Meeting, June 26, 1975.

USDA, Forest Service. Memorandum about Discussions and Proposal for Study, November 26, 1980.

USDA, Forest Service. "Mid-Range Plan for Research Program Development (Fy 1988-92). June and October 1987.

USDA, Forest Service. Milestone: Technology Transfer in the Forest Service. July 1981.

USDA, Forest Service. Miscellaneous Budget Tables. 1983-1988.

USDA, Forest Service. The Pinchot Institute for Conservation Studies. April 1983.

USDA, Forest Service. Protecting and Enhancing America's Forests and Rangelands: 1986 Research Accomplishments. General Technical Report WO-53: December 1987.

USDA, Forest Service. A Recommended Renewable Resources Program: 1985-2030. 1985 update, FS-400: July 1986.

USDA, Forest Service. Report of the Forest Service: Fiscal Year 1985. February 1986.

USDA, Forest Service. Research Needs Identified in Forest Plan: Rocky Mountain Region, Dec. 31, 1986; Southwestern Region, Nov. 28, 1986; NE & NC, Dec. 15, 1986.; Intermountain Research Station, Dec. 31, 1986; Pacific Northwest, Dec. 19, 1986; FPL, Dec. 8, 1986.

USDA, Forest Service. Research Needs Evaluation Progress Report. April 9, 1987.

USDA, Forest Service. The Southeastern Forest Experiment Station's Spirit of Discovery.

USDA, Forest Service. What the Forest Service Does. FS-20.

USDA, Forest Service. 1980-1990 National Program of Research for Forest and Associated Rangeland. General Technical Report WO-32: May 1982.

USDA, Forest Service. "1988 Budget Explanatory Notes for Committee on Appropriations."

USDA, Forest Service, Evaluation Team. "Research Needs in Forest Plans: An Evaluation of Needs Monitoring and the Disposition Process." August 24, 1987.

USDA, The Fishery Program. Rise to the Future: Fish Your National Forests. Brochure.

USDA, Forest Service, Forest Inventory and Economics Research. Forest Service Resource Inventory: An Overview. August 1987.

USDA, Forest Service, Forest Research. "Capability Increase Recommendations, Fiscal Year 1988, April 10, 1987.

USDA, Forest Service, Forest Research. 1988 Appropriation--House and Senate Actions.

USDA, Forest Service, Forest Research. House: Forest Service Briefing Papers, FY 1988, June 10, 1987.

USDA, Forest Service, Forest Research. Profiles of the Research Program. January 28, 1988.

USDA, Forest Service, Forest Research. Senate Questions and Answers. FY 1988 Budget, April 13, 1987.

USDA, Forest Service, Northeastern Forest Experiment Station. Eastern Hardwoods Research Cooperative: A Program Description. nd.

USDA, Forest Service, Northeastern Forest Experiment Station. Spruce - Fir Research Cooperative: A Program Description. nd.

USDA, Forest Service, Northeastern Station. Proceedings: IUFRO Evaluation and Planning of Forestry Research. 1986.

USDA, Forest Service, Personnel and Civil Rights. Work Force 1995: Strength Through Diversity. December 1987.

USDA, Forest Service, Research Improvement Team. Papers. 1986-1987.

USDA, Forest Service, Southeastern Forest Experiment Station. Proceedings of the Southern States Recreation Research. General Technical Report, SE-9: June 1976.

USDA, Forest Service, Southeastern Forest Experiment Station. "Research Unit Descriptions." nd.

USDA, Joint Council on Food and Agricultural Sciences. Fiscal Year 1989 Priorities for Research Extension and Higher Education: A Report to the Secretary of Agriculture. June 1987.

USDA, Research and Education Committee. 1986 Annual Report on the Food and Agricultural Sciences. September 1987.

USDA, Soil Conservation Service. 1987 Soil and Water Conservation Research and Education Progress and Needs. June 1987.

Wildlife Management Institute. Join Us in a Partnership for Wildlife and Fish Management. Nd.

Wood, Jim. "Improving the Role of Science in the National Park Service." Park Science. Vol 8: 2, Winter 1988, 22-23.

Appendix D

STUDY PROJECT:
ASSESSMENT OF THE COMPETITIVENESS OF FOREST SERVICE RESEARCH

Task I Report
Review of Earlier Studies and Literature

November 30, 1987

Task I: Review of Earlier Studies and Literature

Scope and Purpose of This Research Task

A review of earlier studies and literature on R & D management, innovation, science policy, technology transfer, response to change and related topics has been conducted. The purposes of this literature review have been two fold:

- to establish a research background for field work and other activities related to subsequent tasks of this study;
- to search for specific concepts and methodologies that might directly answer the major questions that concern the Forest Service in regard to this study. These are: (a) how can the research competitiveness of a scientific organization be determined and measured, quantitively or at least qualitatively? and (b) how does a research organization remain responsive to the needs for change and maintain the capacity to successfully initiate and develop new programs?

Overview of Task Results

The literature review has substantially achieved the first goal of providing a research background to help guide the balance of the research effort. The documents reviewed thus far have given renewed confidence that the research plan is soundly based on the mainstream of thought in R & D management, stimulation of intellectual creativity, and institutional response to external needs for research results. The concepts discussed in the literature constitute a baseline against which to compare ideas, problems, and questions that are likely to arise in planned interviews with Forest Service officials and research staff, as well as with persons in other organizations—clients, peers, and research staff in complementary or competitive research units.

Progress toward the second goal has been mixed. That is, much of the literature and earlier studies contain concepts about R & D management methods that are too general for specific application to the major questions concerning the Forest Service. Literature on organizational evaluation, for example, in many cases describes organizations that are structurally different from Forest Service Research and have differing needs for evaluation. This is not to say that the literature is useless. Indeed, the literature embodies much of what is known of the management of science. Instead, the literature contains concepts that require selection and adaptation before they can constructively contribute to the concerns of this study. In short, the literature reviewed thus far does not reveal any particular answers that can meet this study's research objectives. This result is the expected one.

What this study task <u>does</u> contribute is to array a number of concepts and

techniques that demonstrate some promise as tools for use in the remainder of the study tasks.

The major questions that concern this study are restated and expanded in the next sections of this report. For each question, some of the more pertinent or promising ideas from the literature are discussed. Their potential application to answering the study questions is described, where this is known.

A. Determining and Measuring Research Competitiveness

A major study question is: What is the relative standing of Forest Service Research in terms of "research competitiveness" vis-a-vis other research organizations that can be classified as peers or competitors and that perform research in the same or related areas? It is apparent that this question needs more specific definition, particularly in the term "research competitiveness." Does "competitiveness" mean quality of research output, and if so, how is quality to be measured and by whom? Does "competitiveness" mean research reputation of the organization as a whole, or of its more prominent scientists, and if so which is the reference group whose opinion as to reputation is of concern? Is it the scientific community as a whole (e.g., members of the AAAS), or the subset of forestry scientists, or the general public, or the influential decision-makers in the executive and legislative branches of the Federal Government?

Or does "competitiveness" mean success in competing for the resources needed by the research organization to survive, grow and excel? These resources may include scientists, to be recruited after doctoral study or in mid-career. They may include funding, for equipment, facilities and salaries that meet a particular standard.

The distinctions are difficult to make because the alternative definitions of competitiveness tend to overlap. That is, the organization that achieves quality tends to achieve enhanced reputation, and by achieving reputation also tends to compete more successfully for resources, i.e., grants, appropriations, scientific recruits. It also is apparent from certain examples that exceptions exist: quality research performers may not enjoy the reputation given to certain more prominent institutions because of persistence of past reputation and the halo effect of institutional achievements unrelated to scientific quality. Also, the allocation of resources may be influenced more by scientific fads or even by the perceived value of the research objectives than by the quality of the research being accomplished.

Given the assumption that agreement can be found on a definition of "research competitiveness," what does the literature reveal concerning the competitiveness of Forest Service Research? Very little is revealed that is specific, at least in the general literature. Some literature, and particularly documents prepared by forest research organizations, will be reviewed in the course of the study and may provide insights. The general literature discusses methods and research techniques that have been used to measure research quality, or at least the perception of research quality

among peers, other scientific authors, etc.

A 1982 NSF report, The Quality of Research in Science, summarizes several studies related to the evaluation of basic research by federal agencies. The evaluation methods used included: peer review; "blind" external review, in which the identity of the scientific investigator was not revealed; quantitative measures of institutional research capability based on the number of individual scientific awards received; duration and turnover of research areas; continuity and concentration of funding; and availability of equipment.

Bibliographic evaluation methods that were used included: publication productivity, as measured by number of articles published proportional to size of research budget; relevance, or quality, of journal articles as measured by quantity of citations in subsequent articles; short-term and long-term relevance, measured by proportion of articles cited in the second year after publication and in the five to ten year period after publication, respectively; and innovativeness, measured by date (time rank) of publication of articles in the field. Another study reviewed a sample of articles in leading scientific journals and scanned them for acknowledgement of financial support from the federal program being evaluated.

Still other evaluations were based on retrospective studies, which first developed a listing of key technological or scientific discoveries, as judged by a panel of experts, then traced the origins of these to determine the relevance of research conducted or funded by a specific agency.

A 1977 study conducted for NSF, Quality Indicators in the Scientific Journal Article Publication Process, used a combination of approaches to judge scientific quality: collection of survey data from authors of scientific articles and from scientists nominated by their peers as competent to judge the scientific merit of articles in terms of an entire scientific field; and the gathering of bibliographic and citation data pertaining to the scientific works published in an earlier period. This study also commented on other methods of judging scientific quality: productivity, i.e., the number of publications per scientist, or a weighted publication count, giving differential weights to books, edited volumes, articles, etc.; citation frequency; scientific recognition, measured by the number and prestige of honors won; and scope of scientific reputation, measured by the percentage of scientists in the discipline who, when surveyed, reported knowing of the work of the subject scientist.

A sizeable portion of the literature deals with methods for program evaluation. Rutman, in Evaluation Research Methods (1977), states that such methods can be applied to programs which (a) can be clearly articulated, i.e. , can be conceptualized in measurable terms and for which operational data can be collected; (b) have clearly specified goals and anticipated effects; and, (c) incorporate a rationale that suggests reasons why the program is expected to reach the stated goals or produce the identified effects. The ability to evaluate a research program, such as Forest Service Research, depends on whether these preconditions exist. Clearly, goal setting is more easily done with a mission-oriented program than with one

that provides general support to an operating organization. Moreover, a program evaluation can measure effectiveness and efficiency of a program in terms of meeting operational goals and of satisfying user needs more easily than it can measure quality. The use of program evaluation methods to measure competitiveness also is difficult unless the programs with which it competes also are evaluated.

Stephanou, in Management: Technology, Innovation & Engineering (1981) acknowledges the difficulty of evaluating groups of research scientists and describes attempts to completely quantify the performance of scientific groups as "challenging, if not impossible, endeavors." He states that "evaluation of group performance can be accomplished by comparison with other similar groups or by consideration of performance criteria that management has designated as being important . . . ." No method is described for evaluation by comparison with other similar groups, which appears to be a form of competitiveness evaluation. For evaluation against performance criteria, which does not directly measure competitiveness, Stephanou suggests such criteria as: Project progress and the meeting of schedule milestones; relationship of actual to budgeted expenditures; quantity of new products or processes developed; communication across functional lines; productivity in publications and patents; avoidance of a high turnover rate; esprit de corps of the group; and level of outside requests for the group's assistance. Evaluations against such criteria will provide some measure of meeting management's expectations but will not directly evaluate scientific quality or competitiveness.

Another major body of literature deals with the management of R & D organizations. This covers several topics: planning and technological forecasting; developing an R & D strategy; resource allocation; organizing and motivating to promote creativity and innovation; project selection and evaluation; program planning and control. This literature says little on how to evaluate R & D organizations from the viewpoints of quality and competitiveness. "Evaluation" is limited to the evaluation of research projects, to aid in selection and decisions to continue or to cease project funding, rather than to evaluation of the research organization as a whole.

Social science research literature contains examples of studies that have attempted to identify the characteristics of scientists that correlate with creativity and scientific performance. For example, Donald Pelz (1963) studied the values, motivations, and social relations, etc., of scientists and compared these with objective measures of scientific performance. Research of this type is potentially useful in selecting scientists for employment in a research organization, but does not hold promise for evaluating the organization itself.

An overview article by Pappas and Remer, "Measuring R & D Productivity," Research Management (May-June 1985), describes several quantitative techniques used by corporate management to measure productivity of an R & D department. These include estimates of potential business income to be realized if new technology resulting from R & D is commercialized; statistics on patents, publications and citations; peer or panel evaluation (semi-quantitative summary of qualitative evaluations); ratings by the division

that uses the results of R & D; and a detailed questionnaire that measures R & D effort in terms of ratings converted to dollar averages. The authors conclude that productivity rating systems have limited accuracy and that peer ratings are generally preferred to other methods.

In summary, the literature review has provided a helpful background for the evaluation of the competitiveness of Forest Service Research and has identified some techniques that show promise in developing quantitative indicators of research quality and competitiveness. However, the techniques that will be utilized have obvious limitations and will require adaptation before use and careful interpretation of results before reaching conclusions.

B. Maintaining Responsiveness To Needs For Change In The Capacity To Initiate and Develop New Programs

Only portions of the general R & D management literature directly address these concerns of Forest Service Research. Much of the "knowledge" that relates to this topic is imbedded in more general or even tangential works. The following summary is representative of that literature which seems to be most appropriate to the concerns of the Forest Service in this area.

In a quasi-military organization like the Forest Service, the importance and centrality of hierarchial authority cannot be overlooked. However, this must be blended with the noetic authority which tends to permeate the research community. This accommodation between authority based upon position and authority based upon knowledge is "classic" in the history of industrial research, which probably has more analogues in terms of internal processes than might other government research organizations where the authority of knowledge appears to be more dominant. Such is typical in the case of medical research at the National Institutes of Health, physical sciences within the Department of Energy laboratories, and engineering technology within the National Aeronautics and Space Administration. To some extent this "culture" also is evident in the Forest Service's sister organization, the Agricultural Research Service.

R & D Must Have a Continuing Role in Top-Level Management

This could be classified as a "truism." If a research organization is to be sustained over any period of time it must have access to top-level management. More likely, it should be a part of top-level management. An important part of the organization, the research and development group should have a research charter, best characterized as a "... shared understanding of the mission that research is expected to fulfill." (Rosenbloom and Kantrow). The emphasis here is upon shared understanding where the Chief Executive and the Director of Research are mutually in tune with one another about the role of the research organization. Some of those roles include the following:

- Innovation: supporting existing operations as well as identifying and contributing to new thrusts;
- Intelligence: providing a window on new science whereby one can

identify both opportunities and challenges;

- o Human Resources: providing an arena for the recruitment and development of talented people; and,

- o Technology Transfer: identifying other sources of technology and facilitating its use.

A key factor related to this question of relationship of the R & D function within the senior management circle is the importance of personal value orientation. The literature is full of data and experience regarding the "natural" conflict between the value orientations of the general manager and that of the scientist. If the organization's Chief Executive comes from experience outside the field of research, one must deal with this possible barrier in perception. However, there well may be other important aspects of the Chief Executive's value orientation that need to be taken into account in developing the most productive relationship between the Director for Research and Development and the Chief Executive. (Hower and Orth).

Another key element relating to top-level management and the role of R & D is the ability and the means by which the R & D Director communicates to the Chief Executive. Particularly where the Director of R & D is a part of a top-level management team, he must be perceived to have the best interests of the general organization in mind and not be seen solely as an advocate for the R & D program or organization. This is particularly important for the successful management of basic research which, typically, requires management patience within an environment of short term requirements. This has been characterized as requiring "... having and communicating a sense of the long flow and cycles of technology, companies and industries, and making a suitable adjustment to them."

Appreciation of User Needs/Market Orientation

The literature reveals that a substantial portion of "failures"—at least in terms of the general organization's appreciation of the R & D organization—relates to an inadequate appreciation on the part of R & D managers for a market orientation. In a public agency this can be translated into meeting user or potential user needs. Depending upon the nature and structure of the parent organization, these market or user needs have important organizational implications. For example, the more that R & D is subject to external influences in its goal determination, the more important it is to develop interorganizational and boundary role mechanisms to facilitate two-way interaction regarding needs, programs, timing, etc. (Radnor and Rich). Much the same is true where the primary users are in-house (such as the case of the National Forest System within the Forest Service). Here it is important to reduce intraorganizational barriers (Mansfield and Wagner). In both instances R & D managers must tend to these interactions between the elements of the research organization and the potential users of research.

The Structure and Processes for R & D Must Fit the Organizational Environment

This has been a concern of many students of R & D management, and one that scholars frequently find missing in attempts to "model" the R & D process generally or in specific organizations. It is also one that makes difficult the application of successful R & D experiences from one organizational setting to another. (Radner and Rich).

One suggestion has been to fit the R & D organization to the parent's organizational imperatives and processes, as these relate to the role of R & D for that particular organization. For instance, it may be that the organizational imperative concerning research is more specifically (1) urgency and (2) predictability. (Gordon, in Yovits et al.). Here urgency is defined as the speed with which results are needed by the sponsor and predictability as being where research objectives are predeterminable. This suggests the need to determine what are the "organizational imperatives" of the Forest Service.

If the R & D organization is to fit the organizational environment, and that environment requires substantial sensitivity to the needs of users or potential users, the R & D organization will have to be structured to permit substantial involvement by those individuals responsible for operations as well as those in research and development with respect to research decisions. This may best be accomplished by at least some organizational decentralization to the field. (Ahlbrandt and Blais).

Setting Goals and Priorities, Judging Results

Any organization, research or otherwise, cannot deal with goal setting or priorities until it has identified its own strengths and weaknesses. In some instances it will be necessary to modify goals or priorities according to an organization's peculiar strengths, particularly where these cannot be supplemented or weaknesses overcome in the short range. However, the organization must confront decisions with respect to resource tradeoffs, generating such questions as whether or not the organization will do certain types of research inhouse or seek the expertise elsewhere, the extent to which particular categories of specialty or talent will be recruited, retrained or reassigned based upon the judgement of needs and current strengths and weaknesses.

Successful research managers in American industry attest to setting priorities based upon the general guidelines of what has the most importance to the particular business, combined with technical opportunity. (Rosenbloom and Kantrow). These elements are a part of the goal setting and priority consideration related to strategic R & D planning. For example, if a particular research program is identified as being highly desirable in terms of its importance to the business, and if it proves successful, will the necessary capital be available downstream to carry the program through to its actual operational phases? Near term, and mid-term decisions regarding possible alternatives need to be carried on to the strategic level to assure the highest degree of utilization and success. The Industrial Research

Institute's Committee on Research-On-Research acknowledged that directed basic research will only succeed if it is selected and directed to those fields where advances are likely to have the most impact on a company's future mainline business. However, (and harking back to the need for close communication with the organization's leadership) the fact that benefits are only likely to occur from five to twenty-five years after basic research has started needs to be made clear. The committee noted that there are intermediate benefits, and that longer term research will have an impact upon major strategic actions and capital investment decisions in the mid-term period. As a means of keeping such research "on-track," the committee suggested that there should be a project termination rate that is "known" and "significant," approaching as much as ten to twenty-five percent per year.

The longer term research benefits are always difficult to judge prior to the time research is completed, but there are a number of indicators that can be used: (1) the development projects that such longer term research spawns; (2) the long range technical contributions that are made to organizational strategies; and (3) "objective" review by outside scientists or technologists (in the latter case it is useful to "sunset" such groups in terms of when their services will end). All in all, the committee makes a strong point of the need for the Research Director to identify the technological future, its trends and factors as they will affect the organization's business and to communicate this effectively to the Chief Executive. (IRI Research-On-Research Committee).

Both businessmen and scholars caution about limiting judgement with respect to the value of any particular research program to its simple economic components--typically within industry this is return on investment. Other values need to be considered such as contribution to an organization or company's product line, the total life cycle returns, and contributions to avoiding dead ends or costly mistakes.

Finally, research organizations (and their parent companies or agencies) need to be prepared for and accept "failure." Here "failure" would be characterized in terms of inability to reach the initially proposed research objectives. Research, by its very nature, is highly uncertain because of a variety of factors such as the uncertainties of: technical progress in associated areas which may be needed for success; the intensity of operational need which may shift; the longevity of operational need which may terminate prior to the completion of research; and, always, the availability of resources. All of these uncertainties combine to promote "failure," but the research process provides opportunities to learn--any of which often prove valuable to the parent organization quite independent of the degree to which the particular research objectives were achieved. All of these things need to be considered in the process of evaluating a general research program or a particular research program.

Implications for Forest Service Research

The literature relevant to responsiveness and decision-making in research organizations has several general implications for this study, perhaps best

stated as questions:

What needs to be done to assure that Forest Service research is put into perspective with all other Forest Service activities?

How can the research organization build upon its and the Forest Service's strengths to provide responsiveness and flexibility?

How can Forest Service research strategy and organization best be made congruent with:

(a) Forest Service general goals,
(b) long-term considerations,
(c) "balance" between external and internal R & D needs,
(d) appropriate consideration of all resources to meet R & D needs?

The first question stems from the notion that research in most organizations is not an end in itself. It is undertaken to meet certain objectives (or contribute thereto) of the organization. As such it must be a part of broader considerations and processes within the organization, and the data collection, planning and decision activities should support top management within that context. This involves consideration of structure, means of communication, and interpersonal relationships, among others.

The second question recognizes the need to clearly define Forest Service (and Forest Service Research's) strengths and weaknesses in relation to its missions and resources--as well as expectations. For example, the Forest Service has the characteristics of a quasi-military organization with well-structured organization and processes, yet it is marked by considerable openness, the opportunity for broad communication, and substantial decentralization. There is considerable opportunity to achieve needed flexibility within a formal hierarchy. Likewise, the reasonably well-defined value system of the Forest Service is an asset because it is not quickly or easily altered by leadership changes, but the organization is small enough so individuals can have substantial influence--based upon knowledge and performance rather than (solely) position or authority. Such factors need to be sorted out with respect to how they can facilitate or inhibit responsiveness.

The final question relates to process and planning of Forest Service research. It needs to contribute to Forest Service goals and the means for achieving them. In doing so, there will be long-term research needs that call for directed basic research which is not always easy to sustain the face of resource scarcity. Some "slack" needs to be permitted, and the means found to protect that, yet meet changing needs. What constitutes "balance" between meeting external (e.g. the profession, private forestry, industry, the Congress) and internal (e.g. NFS) needs will greatly affect the research strategy. That balance is ever shifting and needs to be defined--especially as perceived by Forest Service management. Finally, research organizations tend to become parochial. They need to continually be alert to and use external resources to help meet the research agenda. This is not "natural," but needs management support and attention.

BIBLIOGRAPHY

Books

Allen, Thomas J. Managing the Flow of Technology: Technology Transfer and the Dissemination of Technological Information within the R&D.E. Organization. Cambridge, MA: MIT Press, 1978.

Allison, David, ed. The R&D Game: Technical Man, Technical Managers, and Research Productivity. Cambridge, MA: MIT Press, 1969.

Barber, Bernard, Hirsch, Walter, eds. The Sociology of Science. New York: Free Press of Glencoe, 1962.

Binswanger, Hans P., Ruttan, Vernon W. Induced Innovation: Technology, Institutions, and Development. Baltimore: Johns Hopkins University Press, 1978.

Brooks, Harvey. The Government of Science. Cambridge, MA: MIT Press, 1968.

Burns, Tom, Stalker, G.M. The Management of Innovation. London: Tavistock Publications, 1961.

Cetron, Marvin J., Bartocha, Bodo, eds. The Methodology of Technology Assessment. New York: Gordon and Breach, 1972.

Cetron, Marvin J., Goldhar, Joel D., eds. The Science of Managing Organized Technology. New York: Gordon and Breach, 1970.

Chapman, Richard L. Project Management in NASA: The System and the Men. Washington, D.C.: GAO, 1973.

Cleland, David I., King, William R. Systems Analysis and Project Management. London: McGraw-Hill Book Company, 1968.

Coler, Myron A., ed. Essays on Creativity in the Sciences. New York: NYU Press, 1963.

Craig, John R., Cunningham, Donald E., Schlie, Theodore W., eds. Technological Innovation: The Experimental R & D Incentives Program. Boulder, CO: Westview Press, Inc., 1977.

Crane, Diana. Invisible Colleges: Diffusion of Knowledge in Scientific Communities. Chicago: University of Chicago Press, 1972.

Daumas, Maurice, ed. A History of Technology and Invention: Progress Through the Ages. New York: Crown Publishers, 1969.

Dean, Burton V., Goldhar, Joel, eds. Management of Research and Innovation. New York: North-Holland Publishing Co., 1982.

Edwards, George C. Implementing Public Policy. Washington, D.C.: Congressional Quarterly Press, 1980.

Enke, Stephen. Defense Management. Englewood Cliffs: Prentice Hall, 1967.

Evans, C. George. Supervising R&D Personnel. New York: American Management Association, 1969.

Ewing, David W., ed. Technological Change and Management. Boston: Harvard Business School, 1970.

Ford, Henry. A Normative Model of R&D Project Selection Under Uncertainty. University of Pennsylvania dissertation, 1978.

Gerstenfeld, Arthur. Innovation: A Study of Technological Policy. Washington, D.C.: University Press of America, 1979.

Gilfillan, S.C. The Sociology of Invention. Cambridge, MA: MIT Press, 1963.

Glaser, Barney G. Organizational Scientists: Their Professional Careers. Indianapolis: Bobbs-Merrill, 1964.

Gold, Bela. Productivity, Technology and Capital: Economic Analysis, Managerial Strategies, and Government. Lexington, MA: Lexington Books, 1979.

Gold, Bela, Rosegger, Gerhard, Boyland, Myles G. Evaluating Technological Innovations: Methods, Expectations, Findings. Lexington, MA: Lexington Books, 1982.

Goslin, Lewis N. A Selected Annotated Bibliography on R&D Management. Indiana University, Bureau of Business Research, 1966.

Granstrand, Ove. Technology, Management and Markets: An Investigation. New York: St. Martin's Press, 1982.

Habakkuk, H.J. American and British Technology in the Nineteenth Century: The Search for Labour-Saving Inventions. Cambridge: Cambridge University Press, 1962.

Hawthorne, Edward P. The Management of Technology. London: McGraw-Hill, 1978.

Holt, Arthur L. Design and Test of a Sponsor's Measure of Effectiveness for Scientific and Technical Information Centers. Ohio State University dissertation, 1967.

Hower, Ralph M., Orth, Charles D. Managers and Scientists: Some Human Problems in Industrial Research Organizations. Boston: Harvard Business School, 1963.

Johnson, Richard A., Kast, Fremont E., Rosenzweig, James E. The Theory and Management of Systems, Second Edition. London: McGraw-Hill Book Company, 1963, 1967.

Lawrence, Paul R. Lorsch, Jay W. Organization and Environment: Managing Differentiation and Integration. Boston: Harvard Business School, 1967.

Lundstedt, Sven, B., Colglazier, E. William, eds. Managing Innovation: The Social Dimensions of Creativity, Invention and Technology. New York: Pergamon Press, 1982.

Maciariello, Joseph A. Program Management Control Systems. New York: John Wiley, 1978.

Mason, Otis T. The Origins of Invention: A Study of Industry Among Primitive Peoples. Cambridge, MA: MIT Press, 1985.

Mazlish, Bruce, ed. The Railroad and the Space Program: An Exploration in Historical Analogy. Cambridge, MA: MIT Press, 1965.

Mowbray, George Rutman, Leonard. Understanding Program Evaluation. Beverly Hills, CA: Sage Publications, Inc., 1983.

Nelkin, Dorothy. Controversy, Politics of Technical Decisions. Beverly Hills, CA: Sage Publications, Inc., 1979.

Orlans, Harold. The Nonprofit Research Institute. London: McGraw-Hill Book Company, 1972.

Parker, R.C. The Management of Innovation. New York: John Wiley, 1982.

Patton, Michael Q. Utilization-Focused Evaluation. Beverly Hills, CA: Sage Publications, Inc., 1978.

Pelz, Donald C., Andrews, Frank M. Scientists in Organizations: Productive Climates for Research and Development. Ann Arbor: University of Michigan Institute for Social Research, 1976.

Price, Derek J. de Solla. Science Since Babylon. New Haven: Yale University Press, 1961.

Roman, Daniel D. Research and Development Management: The Economics and Administration of Technology. New York: Appleton-Century-Crofts, 1968.

Rothman, Jack. Using Research in Organizations. Beverly Hills, CA: Sage Publications, Inc., 1980.

Rutman, Leonard, ed. Evaluation Research Methods: A Basic Guide. Beverly Hills, CA: Sage Publications, Inc., 1977.

Rutman, Leonard. Planning Useful Evaluations. Beverly Hills, CA: Sage Publications, Inc., 1980.

Ryan, William G., Steiner, George A. Industrial Project Management. New York: The Macmillan Company, 1968.

Salasin, John, ed. The Management of Federal Research and Development: An Analysis of Major Issues and Processes. McLean, VA: Mire Corp, 1977.

Sayles, Leonard R. and Margaret K. Chandler. Managing Large Systems. New York: Harper & Row, 1971.

Shils, Edward, ed. Criteria for Scientific Development: Public Policy and National Goals. Cambridge, MA: MIT Press, 1968.

Sporn, Philip. Technology, Engineering and Economics. Cambridge, MA: MIT Press, 1969.

Stephanou, S.E. Management: Technology, Innovation and Engineering (A Systems Approach). Malibu, CA: Daniel Spence Publishers, 1981.

Taylor, Calvin W., Barron, Frank, eds. Scientific Creativity: Its Recognition and Development. (Selected papers from the Proceedings the 1st, 2nd, and 3rd University of Utah Conferences, "The Identification of Creative Scientific Talent." New York: John Wiley, 1963.

Teich, Albert H., ed. Science, Technology, and the Issues of the Eighties: Policy Outlook. Boulder, CO: Westview Press, 1982.

Twiss, Brian. Managing Technological Innovation. New York: Longman Group Limited, 1974.

Villers, Raymond. Research and Development: Planning and Control. New York: Rautenstrauch and Villers, 1964.

Voos, Henry. Organization Communication: A Bibliography. New Brunswick, NJ: Rutgers University Press, 1967.

Webb, James E. Space Age Management: The Large Scale Approach. New York: McGraw-Hill, 1969.

Yovits, M.C., ed. Research Program Effectiveness. Proceedings of the Conference sponsored by the Office of Naval Research. Washington, D.C.: 1966.

Reports

National Academy of Sciences. Quality of Research in Science: Methods for Post Performance Evaluation in the National Science Foundation. Washington, D.C.: NAS, 1982.

General Accounting Office. Regulatory Effects on R&D are Better Assessed as Part of the Innovation Process. Gaithersburg, MD: Economic Research Service, 1977.

National Science Foundation. Digests of R&D Organization and Management Studies. Washington, D.C.: NSF, 1966.

Harvard Business Review. The Management of Technological Innovation. Boston: author, 1982.

Booz, Allen Applied Research. Government Procurement as an Incentive to Commercial Technology and Innovation. np: author, 1973.

National Science Foundation. Studies of Scientific Disciplines. Washington, D.C.: author, 1983.

National Science Foundation. Role of Basic Research in Science and Technology: Case Studies in Energy R&D--Workshop Highlights and Papers. Washington, D.C.: NSF, 1983.

Office of Technology Assessment. Technology Assessment in Business and Government--Summary and Analysis. Washington, D.C.: GPO, 1977.

American Management Association. Creativity: Key to Continuing Progress. New York: author, 1960.

W.E. Upjohn Institute for Employment Research. Management in the Scientific Age: Proceedings 1958 Annual Conference of the Washington Chapter for Advancement of Management. Kalamazoo, MI: author, 1961.

Conference on the Administration of Research. Proceedings of the 20th National Conference on the Administration of Research. Denver: author, 1967; 21st, 1968.

General Accounting Office. Mission Budgeting: Discussion and Illustration of the Concept in Research and Development Programs. Washington, D.C.: author, 1977.

General Accounting Office. Program Evaluation: Legislative Language and User's Guide to Selected Sources. Washington, D.C.: author, 1973.

Westat Research, Inc. Procedural Guide for the Evaluation of Document Retrieval Systems. Bethesda, MD: author, 1968.

Abt Associates, Inc. Report of a Survey of the State of the Art: Social, Political, and Economic Models and Simulations. Cambridge, MA: author, 1965.

NASA Langley. Management, A Continuing Literature Survey--with Indexes. Washington, D.C.: author, 1968.

Illinois Institute of Technology, University of Illinois. Proceedings of the 22nd National Conference on the Administration of Research. Chicago: author, 1968.

International City Managers' Association. Program Development and Administration. Chicago: author, 1965.

American Society of Mechanical Engineers. Managing for Improved Engineering Effectiveness. New York: author, 1972.

National Academy of Engineering. Engineers at Work. Washington, D.C.: author, 1968.

National Academy of Engineering. The Process of Technical Innovation. Washington, D.C.: National Academy of Sciences, 1969.

National Academy of Sciences, National Research Council. Useful Application of Earth-Oriented Satellites: Volume 1, Forestry-Agriculture-Geography. Washington, D.C.: 1969.

National Academy of Sciences, National Academy of Engineering. Scientific and technical Communication: A Pressing National Problem and Recommendations for Its Solution. A Synopsis. Washington, D.C.: 1969.

Northwestern University Technological Institute. Program of Research on the Management of Research and Development. Evanston, IL: 1970.

National Science Foundation. Digests of R&D Organization and Management Studies. Washington, D.C., August 1966.

National Industrial Conference Board. The Challenge of Technology: Linking Business, Science, and the Humanities in Examining Management and Man in the Computer Age. New York: 1967.

Department of the Navy, Headquarters, Naval Material Command. Configuration Management: A Policy and Guidance Manual. Washington, D.C.: 1967.

Alfred P. Sloan School of Management, MIT. Annual Report--Research Program on the Management of Science and Technology, 1964-65. Cambridge, MA: 1965.

Arthur D. Little. Management Factors Affecting Research and Exploratory Development. Cambridge, MA: 1965.

National Science Foundation. National Patterns of R&D Resources: Funds and Manpower in the United States, 1953-70. Washington, D.C.: Government Printing Office, 1969; 1953-76, 1976.

Stanford Research Institute. The Structure and Dynamics of the R&D Industry with Special Reference to NASA Programs in the Los Angeles Area. Menlo Park, CA: 1965.

U.S. Dept. of Labor, Bureau of Labor Statistics. The Meaning and Measurement of Productivity. Washington, D.C.: GPO, 1971.

Comptroller General of the U.S. Administration and Management of the Biology and Medicine Research Program. Washington, D.C.: GAO, 1969.

U.S. Department of Commerce, Panel on Invention and Innovation. Technological Innovation: Its Environment and Management. Washington, D.C.: 1967.

Columbia University, Bureau of Applied Research. Formal and Informal Satisfaction of the Information Requirements of Chemists. New York: 1966.

Harvard University, Graduate School of Business Administration. Managing Technology Change. Cambridge, MA: 1962.

George Washington University Program of Policy Studies and Technology. Seminar on Social Change in the American Values System. Washington, D.C.: 1967.
1970 Report.

Adams, Elizabeth B, Rood, Sally A. Critical Issues in Scientific and Technical Communication: Perceptions of Users, Providers and Policymakers. Washington, D.C.: George Washington University, 1978.

Allen, Thomas J. Research Program on the Organization and Management of R&D: The Utilization of Information Sources During R&D Proposal Preparation. Cambridge, MA: MIT Press, 1964.

Allen, Thomas, J. Sources of Ideas and Their Effectiveness in Parallel R&D Projects. Cambridge, MA: MIT Press, 1965.

Allen, Thomas J. Research Program on the Organization and Management of R&D: Problem Solving Strategies in Parallel Research and Development Projects. Cambridge, MA: MIT Press, 1965.

Allen, Thomas J., Gerstenfeld, Arthur, Gerstberger, Peter G. The Problem of Internal Consulting in Research and Development Organizations. Cambridge, MA: MIT Press, 1968.

Amesse, Arthur P. The Aspect of Organizational Climate in Research and Development Management. Ft. Belvoir, VA: Defense Systems Management School, 1974.

Barth, Richard T. The Relationship of Intergroup Organizational Climate with Communication and Joint Decision Making Between Task-Interdependent R&D Groups. Northwestern University, dissertation, 1970.

Barth, Richard T., Rubenstein, Albert H., eds. A Directory of Research on Research. Evanston, IL: Northwestern University, 1979.

Bayton, James A. Transformation of Scientists and Engineers into Managers. Washington, D.C.: GPO, 1972.

Becker, Selwyn, W., Stafford, Frank. Some Determinants of Organizational Success. 1967.

Brooks, Harvey. Can Science Be Planned? Cambridge, MA: Harvard University, 1967.

Brown, Fred R., Chitwood, Stephen R. Highlights from the Literature on Organization for Federal Programs in Science and Technology. Washington, D.C.: Commission on Marine Science, Engineering and Resources, 1968.

Brumm, Harold J., Tapiero, Judith, Wise, Donald E. The Impact of Public R&D on Patenting and on Scientific Manpower Retention by Firms in the Private Sector. Princeton, NH: Mathtech, Inc., 1981.

Byatt, ICR, Cohen, AV. An Attempt to Quantify the Economic Benefits of Scientific Research. London: Her Majesty's Stationery Office, 1969.

Carter, Launor F. Knowledge Production and Utilization in Contemporary Organizations. Santa Monica, CA: System Development Corp, 1967.

Churchman, C.W., Kruytbosch, C.E., Ratoosh, P. The Role of the Research Administrator. Berkeley, CA: Space Sciences Laboratory, 1965.

Clauser, Henry R., ed. Research Management. New York: Interscience Pub., 1970.

Cravens, David W. An Exploratory Study of Individual Information--Processing and Decision-making. Bloomington, IN: Aerospace Research Applications Center, 1967.

Dobrov, G.M. Criteria of Choice: A Complex Problem of the Science of Science. Indianapolis, IN: Aerospace Research Applications Center, 1969.

Douds, Charles F. The Effects of Work-Related Values on Communication Between R&D Groups. Evanston, IL: Northwestern University, dissertation, 1970.

Dyer, W. Gibb. Organizational Culture: Analysis & Change. Cambridge, MA: MIT, Salon School of Management, 1983.

Essers, Florence, Rabinow, Jacob,eds. The Public Need and the Role of the Inventor: Proceedings of a Conference Held in Monterey, CA, June 11-14, 1973.

Ettlie, John E. A Real-Time Case Study of Organization and Innovation. Evanston, IL: Northwestern University, 1971.

Gajda, Victor A., Borseth, Earl E. Management Techniques: A Bibliography. Detroit, MI: Center for Applications of Sciences and Technology, Wayne State, 1967.

Goddard, Frank E., Bayley, William H., Carlisle, David K. A Technique for Estimating Funding and Manpower Requirements for Research and Development Long-range Planning. Pasadena, CA: JPL,1962.

Goodman, A.F. Flow of Scientific and Technical Information: The Results of a Recent Major Investigation. Huntington Beach, CA: Douglas Aircraft Co., 1967.

Goodman, Richard A. Organizational Effects Upon Manpower Utilization in Research and Development. St. Louis: Washington University, 1967.

Gottfredson, Stephen D., Garvey, W. D., Goodnow, J.E. Quality Indicators in the Scientific Journal Article Publication Process. Baltimore, MD: Johns Hopkins University, 1977.

Graham, Warren R., Wagner, Clinton B., Gloege, William P. Exploration of Oral/Informal Technical Communications Behavior. Silver Spring, MD: American Institute for Research, 1967.

Griliches, Zvi, Nadiri, M.I. Patents, R&D, and the Private Value of Knowledge: Explorations in the Economics of Technological Change. New York: National Bureau of Economic Research, 1982.

Grubber, Jack A. Utilization of Technology Transfer Concepts as an Aid for Engineering Management in a Test and Evaluation Organization. Monterey, CA: Naval Post Graduate School, master's thesis, 1976.

Havelock, Ronald G., Mann, Floyd C. Research and Development Laboratory Management Knowledge Utilization Study. Ann Arbor: University of Michigan, 1968.

Hax, Arnoldo C., Majluf, Nicolas S. Organization Design. Cambridge, MA: MIT, 1979.

Hinrichs, John R. Creativity in Industrial Scientific Research: A Critical Survey of Current Opinion, Theory, and Knowledge. New York: American Management Association, 1961.

Johnson, Robert E., McKie, James W. Competition in the Reprocurement Process. Santa Monica, CA: Rand Corp, 1962.

Jones, Martin V. A Technology Assessment Methodology. Washington, D.C.: Mitre Corp, 1971.

Klauss, Rudi, Bass, Boward, DeMarco, John J. The Impact of Organization Size and Technology on Managerial Communication Style, Its Credibility and Consequence. Syracuse: Syracuse University, 1978.

Kranzberg, Melvin. Historical Aspects of Technology Assessment. Washington, D.C.: George Washington University, 1969.

Lang, James D. Creativity and Innovation in Defense Technology and Strategy. Washington, D.C.: Industrial College of the Armed Forces, 1983.

Levine, Arnold S. Managing NASA in the Apollo Era. Washington, D.C.: NASA, 1982.

Livermore, Shaw, Cowan, Thomas A. Management of Science Future Guidance and Leadership in Science and Technology: Paradoxes of Science and Administration. Washington, D.C.: George Washington University, 1965.

Mansfield, Edwin. Market Structure, International Technology Transfer, and the Effects on Productivity of the Composition of R&D Expenditures: Executive Summary. Philadelphia, PA: University of Pennsylvania, 1980.

Marquis, Donald G., ed. Research Program on the Management of Science and Technology, Second Report: 1965-67; Annual Report: 1964-65; Annual Report: 1965-67. Cambridge: MIT, nd.

Mayo, Louis H. Scientific Method, Adversarial System, and Technology Assessment. Washington, D.C.: George Washington University, 1970.

McEachron, Norman B. Management of Federal R&D for Commercialization: Appendices; Executive Summary; Supporting Documentation; Final Report. Menlo Park, CA:, SRI International, 1978.

McLoughlin, William G. The Case for Research Accountability. New York: American Management Association, 1967.

McWhinney, William H. On Organizational Aging in an R&D Facility. Los Angeles: University of California, 1966.

Milliken, J. Gordon, Morrison, Edward J. Aerospace Management Techniques: Commercial and Governmental Applications. Denver: Denver Research Institute, 1971.

Milliken, J. Gordon, Morrison, Edward J., Christiano, Carole R. Aerospace Contributions to Management: Selected Cases Illustrating Significant Management Techniques and Computer Software Transferred from U.S. Air and Space Programs. Denver: Denver Research Institute, 1975.

Nadiri, M. Ishaq. A Report on the Determinants of Research and Development Expenditures and Their Effects on Labor Productivity for the Firm. New York: National Bureau of Economic Research, 1975.

Nelson, Richard R. The Economics of Invention: A Survey of the Literature. Santa Monica, CA: Rand Corp, 1958.

Nevins, J.L., Kamrany, N., Whitney, D.E. Product System Productivity Research: A Collaborative Study. Volume 2, Productivity, Technology, and Productivity Research. Cambridge, MA: MIT Center for Policy Alternatives, 1976.

Abhorrer, J. Case Studies Examining the Role of Government R&D Contract Funding in the Early History of High Technology Companies. Cambridge, MA: Research and Planning Institute, Inc., 1980.

Old, Bruce S. Return on Investment in Basic Research--Exploring a Methodology. Concord, MA: Office of Naval Research, 1981.

Olson, Edwin E. Organizational Factors Affecting the Flow of Scientific and Technical Information in Industrial R&D Divisions. Rockville, MD: Westat, Inc., 1978.

Ouchi, William G., Barney, Jay B., Ulrich, Dave. Program for Research on Organizations and Management: The United States-Japanese Electronic Industries Study. Los Angeles: UCLA, Graduate School of Management, 1981.

Proust, Roy. Analysis of Problems Encountered in R&D Project Management. Cambridge, MA: MIT, 1966.

Quesada, Gustavo M. On the Diffusion of Innovations Research Traditions. Holloman AFB, NM: Office of Research Analyses, 1969.

Radnor, Michael, Feller, Irwin, Rogers, Everett. The Diffusion of Innovations: An Assessment. Evanston, IL: Northwestern University, 1978.

Roberts, Edward B. Life Cycles of R&D Organizations. Cambridge, MA: MIT, 1967.

Roberts, Edward B. Questioning the Cost/Effectiveness of the R&D Procurement Process. Cambridge, MA: MIT, 1965.

Rosenberg, Nathan, Mowery, David. Development and Organization of Industrial Research and Development, Final Report. Stanford: Stanford University Department of Economics, 1981.

Rubenstein, Albert H., Sullivan, Edward M. A Directory of Research-on-Research. Evanston, IL: Northwestern University, 1968.

Rubin, Irwin M. Project Management and the Role of the Project Manager. Massachusetts Institute of Technology, 1966.

Shallar, Herman I. An Exploratory Study in Research Planning Methodology. Washington, D.C.: Office of Naval Research, 1963.

Shapero, Albert, Howell, Richard P. Tombaugh, James R. An Exploratory Study of the Structure and Dynamics of the R&D Industry. Menlo Park, CA: SRI, 1964.

Stanic, Vladimir, Pym, Dennis. Brains Down the Drain: The Misuse of Highly-Qualified Manpower. London: Anbar Publications Ltd., 1968.

Steiner, George A. Ryan, William G. Managerial Methods of Successful Project Managers with a Loose Rein. Los Angeles: University of California, 1965.

Stockfish, J.A. Incentives and Information Quality in Defense Management. Santa Monica, CA: Rand Corp, 1976.

Sulkin, M.A., Parsons, T.R., Sinizer, D.I. Frontiers of Technology Study: Volume III, Implementation Requirements Study. Transportation System Technology, 1968.

Sweezy, Eldon E. Managerial Concepts for Laboratory Institutions. Bethesda, MD: np, 1958.

Teich, Albert H. International Politics and International Science: A Study of Scientists' Attitudes. Cambridge, MA: MIT, 1969.

Thornton, Robert.L. Airline Management and the Innovative Process. Ann Arbor: University of Michigan, 1967.

Vollmer, Howard M. Adaptations of Scientists in an Independent Research Organization: A Case Study. Menlo Park, CA: SRI, 1963.

Vollmer, Howard. A Preliminary Investigation and Analysis of the Role of Scientists in Research Organizations. Menlo Park, CA: SRI, 1962.

Waks, Norman. Problems in the Management of Federal Contract Research Centers. Bedford, MA: Mitre Corp, 1970.

Welles, John G., Coddington, Dean C., Milliken, J. Gordon. Contract Research and Development Adjuncts of Federal Agencies: An Exploratory Study of Forty Organizations. Denver: Denver Research Institute, 1969.

Williams, Leslie R., Clark, Sidney E. The Administration of Research. University of Delaware, 1966.

Wolek, Francis W. The Complexity of Messages in Science and Engineering: An Influence on Patterns of Communication. Philadelphia: Wharton School, University of Pennsylvania, 1970.

Wolek, Francis W. Engineering Roles in Development Projects. Philadelphia: University of Pennsylvania, 1970.

Young, Mary E. Research Management: A Bibliography with Abstracts. Springfield, VA: NTIS, 1976.

deLeon, Peter. The Evaluation of Technology R&D: A Continuing Dilemma. Santa Monica, CA: Rand, 1981.

Articles and Papers

Ahlbrondt, Roger S. Jr. and Andrew R. Blair. "What It Takes For Large Organizations to Be Innovative." Research Management. Vol 29, No. 2: 34-37.

Allen, Thomas J. "Studies of the Problem-Solving Process in Engineering Design." IEEE Transactions on Engineering Management. Vol. EM-13, (June 1966): 72-83.

Badaway, Michael K., "How to Prevent Creativity Mismanagement," Research Management. July/August 1986, pp.28-35.

Bagchi, Amiya K. "On the Political Economy of Technological Choice a and Development." Cambridge Journal of Economics. 2(1978): 215-232

Baker, Norman R., Siegman, Jack. "The Effects of Perceived Needs and Means on the Generation of Ideas for Industrial Research and Development Projects." IEEE Transactions on Engineering Management. Vol. EM-14, 4(December 1967): 156-163.

Baker, Norman R., Stephen G. Green and Alden S. Bean. "How Management Can Influence The Generation of Ideas." Research Management. Vol 28, No. 6: 35-42.

Balachandro, R. and Joseph A. Raelin. "When to Kill That R & D Project." Research Management. Vol. 27, No. 4:" 30-33.

Balthasar, Hans U., Boschi, Roberto A., Menke, Michael M. "Calling the Shots in R&D." Harvard Business Review. (May-June 1978): 151-160.

Balthasar, H.U., Gutzwiller, St. "Steady State and Portfolio Concept in R&D Management." R&D Management. (1975): 201-207.

Bare, Bruce M. "Direction of R&D Via Marketing." Chemical Engineering Progress. (1966): 259-267.

Barnes, Carl E. "To Promote Invention." International Science and Technology. (December 1966): 67-73ff.

Barth, Richard T. "Aging, Creativity, Inter-speciality Mobility, Retraining, and Technical Obsolescence of Scientific and Technical Personnel: A Selected Bibliography." January 1970.

Beal, George M., Rogers, Everett M. "The Scientist as Referent in the Communication of New Technology." Public Opinion Quarterly. Vol. XXII, 4(Winter 58-59): 555-563.

Benjamin, Ralph. "Putting the Manager in the Picture." New Scientist. (September 28, 1967): 665-668.

Boyer, R., Selby, T., Tefft, T. "Dynamics of Invention." (1968).

Braunstein, Yale M., Baumol, William J., Mansfield, Edwin. "The Economics of R&D." Management of Research and Innovation. (1980): 19-32.

Brozen, Yale. "Invention, Innovation, and Imitation." American Economic Review. (1951): 239-257.

Cherns, Albert B. "Relations Between Research Institutions and Users of Research." International Social Science Journal. Vol. 22, (November 22, 1970): 226-242.

Cordies, David, Marcus J. Fuhrer, Anne W. Martin and Robert M. Thrall. "Use of Benefit-Cost Analysis in the Peer Review of Proposed Research." Management Science, Vol. 28, No. 4: 439-445.

Crane, Diana. "The Gatekeepers of Science: Some Factors Affecting the Selection of Articles for Scientific Journals." American Sociologist. (November 1967): 195-201.

Dalessio, Anthony. "Academic Success and Job Performance of Engineering and Scientific Personnel." IEEE Transactions on Engineering Management, Vol. EM-33, No. 2: 67-71.

De Meuse, Kenneth P., John W. Louisbury and Steven R. Gordon. "Assessing on R & D Contract Management Process." Research Management, Vol. 24. (July 1981): 30-35.

Dodson, E.N. "A General Approach to Measurement of the State of the Art and Technological Advance." Technological Forecasting. (1970): 391-401.

Drucker, Peter F. "Twelve Fables of Research Management." Harvard Business Review. (1963): 103-108.

Feller, Irwin. "A Managerial Response to Technological Innovation in Public Sector Organizations." Management Science, Vol. 26, No. 10: 1021-1030.

Feller, Irwin. "Technology Transfer, Public Policy, and the Cooperation Extension Service-OMB Imbroglio." Journal of Policy Analysis and Management, Vol. 6, No. 3: 307-327.

Foster, Richard N. "A Call for Vision in Managing Technology." Business Week. (May 24,1982): 24-33ff.

Gage, Stephen, Samuel Rondberg and Terry Schmidt. "How EPA Revamped Its R & D Management Effort." Research Management. July 1981, Vol. 24: 36-40.

General Electric Aerospace Group. "Managing for Effective Cost/Schedule and Technical Performance." Aerospace Management.

Greenwald, Ruth. "Companies Need to Establish Climate That Fosters Innovation." Industrial Engineering, Vol. 17, No. 4: 10-12.

Griliches, Zvi. "R&D and the Productivity Slowdown." American Economic Review. (May 1980): 343-348.

Hayes, Robert H., Abernathy, William J. "Managing as if Tomorrow Mattered." Harvard Business Review. (May-June 1982): 70-79.

Hill, R.B. "The Improvement of Returns from Research and Development Investment." Advancement of Science. (March 1969): 269-278.

Iizuka, Akio. "The Spirit of Harmonious Competition." Technology Review. (August-September 1982): 53-54.

Jackson, Byron. "Decision Methods for Evaluating R & D Projects." Research Management, Vol. 26, No. 4: 16-22.

Kanter, Rosabeth Moss, "Quality Leadership and Changes." Quality Progress, February 1987, pp. 45-51.

Kantrow, Alan M. "Industrial R & D: Looking Back to Look Ahead." Harvard Business Review, July-August 1986: 40-52.

Kierulff, Herbert E., Sr. "Business Venture Development and Evaluation." Journal of Business, Seton Hall University.

Kline, Stephen J. "Innovation Is Not A Linear Process." Research Management, Vol 28, No. 4: 36-45.

Kovack, Kenneth A. and Barry Render, "NASA Managers and Challenges: A Profile and Possible Explanation," Personnel, Aparil 1987, pp. 40-44.

Maher, P. Michael, Rubenstein, Albert H. "Factors Affecting Adoption of a Quantitative Method for R&D Project Selection." Management Science. Vol. 21, 2(October 1974): 119-129.

Mansfield, Edwin. "How Economists See R&D." Harvard Business Review. (November-December 1981): 98-106.

May, William F. "Research into Research." Michigan Business Review. (March 1966): 1-6.

Mechlin, George F., Berg, Daniel. "Evaluating Research--ROI Is Not Enough." Harvard Business Review. (September-October 1980): 93-99.

Mendell, Stefanie and Daniel M. Ennis. "Looking at Innovation Strategies." Research Management, Vol 28, No. 3: 33-40.

Merton, Ulrich and S.M. Ryer. "What Does the R & D Function Actually Accomplish?" Harvard Business Review, July-August 1983: 24-28.

Morton, Jack A. "A Systems Approach to the Innovation Process: Its Use in the Bell System." Business Horizons. (Summer 1967): 27-36.

Mueller, Dennis C., Tilton, John E. "Research and Development Costs as a Barrier to Entry." Canadian Journal of Economics. Vol. II, 4(November-December 1969): 570-579.

Muncaster, John W. "Picking New Product Opportunities." Research Management, Vol. 24 (July 1981): 26-29.

National Science Foundation. "Decision-Making on Research and Development in the Business Form." Government Printing office, nd.

Pappas, Richard A. and Donald S. Remer. "Measuring R & D Productivity." Research Management, Vol 28, No. 3: 15-22.

Price, William J., Bass, Lawrence W. "Scientific Research and the Innovative Process." Science. 164(May 16, 1969): 802-806.

Pryor, Harold E. "An Evaluation of the NASA Scientific and Technical Information System." Special Libraries. Vol. 66, 11(November 1975): 515-.

Reiss, Howard, Balderston, Jack. "The Usefulness of Scientists." International Science and Technology. (May 1966): 38-44ff.

Roberts, Edward B. "Research on the Management of Technology-Based Enterprises." IEEE Transactions on Engineering Management. Vol. EM-11, (1964): 91-102.

Roberts, E.B., Sloat, J.B. "Effects of Incentive Contracts in Research and Development: A Preliminary Research Report." IEEE Transactions on Engineering Management. Vol. EM-13, 4(December 1966): 181-187.

Schoen, Donald R. "Managing Technology Innovation." Harvard Business Review. Vol. 47, 3(May-June 1969): 156-167.

Shapero, Albert. "Managing Creative Professionals." Research Management, Vol. 28, No. 2: 23-28.

Souder, William E. "Stimulating and Managing Ideas." Research Management, Vol. 30, No. 3: 13-17.

Souder, William E. "The Validity of Subjective Probability of Success Forecasts by R&D Project Managers." IEEE Transactions on Engineering Management. Vol. EM-16, 1(November 1979): 35-49.

Spharim, Ishai and Robert Szakonyi. "A Simple Method for Evaluation and Selection of R & D Proposals for a Competitive Grant Fund." IEEE Transactions on Engineering Management, Vol: EM-31, No. 4: 184-185.

Tewksbury, J.G., Crandall, M.S., Crane, W.E. "Measuring the Societal Benefits of Innovation." Science. Vol. 209, 4457(August 8, 1980): 658-662.

Thompson, Charles W. "Selected References on the Administration of Research and Development." Northwestern University, 1967.

Wolff, Michael F. "To Motivate, Set Goals." Research Management, Vol. 28, No. 6: 9-12.

Yaney, Joseph P. "The Management of Innovation." Personnel Journal. (March 1970): 224-5.

Appendix E

STUDY PROJECT:
ASSESSMENT OF THE COMPETITIVENESS OF FOREST SERVICE RESEARCH

Task II Report
The Management of Program Change in the Forest Service

January 15, 1988

Task 2

The Management of Program Change in the Forest Service

The purpose of this task is to describe the Forest Service's means to undertake changes in its ongoing program of research. It is to serve as a starting point to assess the effectiveness of program change in Task 3. This Task Report is based primarily upon the review and analysis of Forest Service documents, reports, studies, congressional hearings, and the like. This was supplemented by limited consultation with Forest Service officials. It will be "tested" more systematically by feedback comments from reviewers and through structured interviews in the preliminary stage of Task 3.

A. The Research Planning and Decision Process in the Forest Service

The Forest Service's research planning and decision process will be described in two parts: (1) The system's structure and formal process, followed by (2) those informal factors or practices which influence the way that the process actually operates.

1. The System Structure and Formal Process

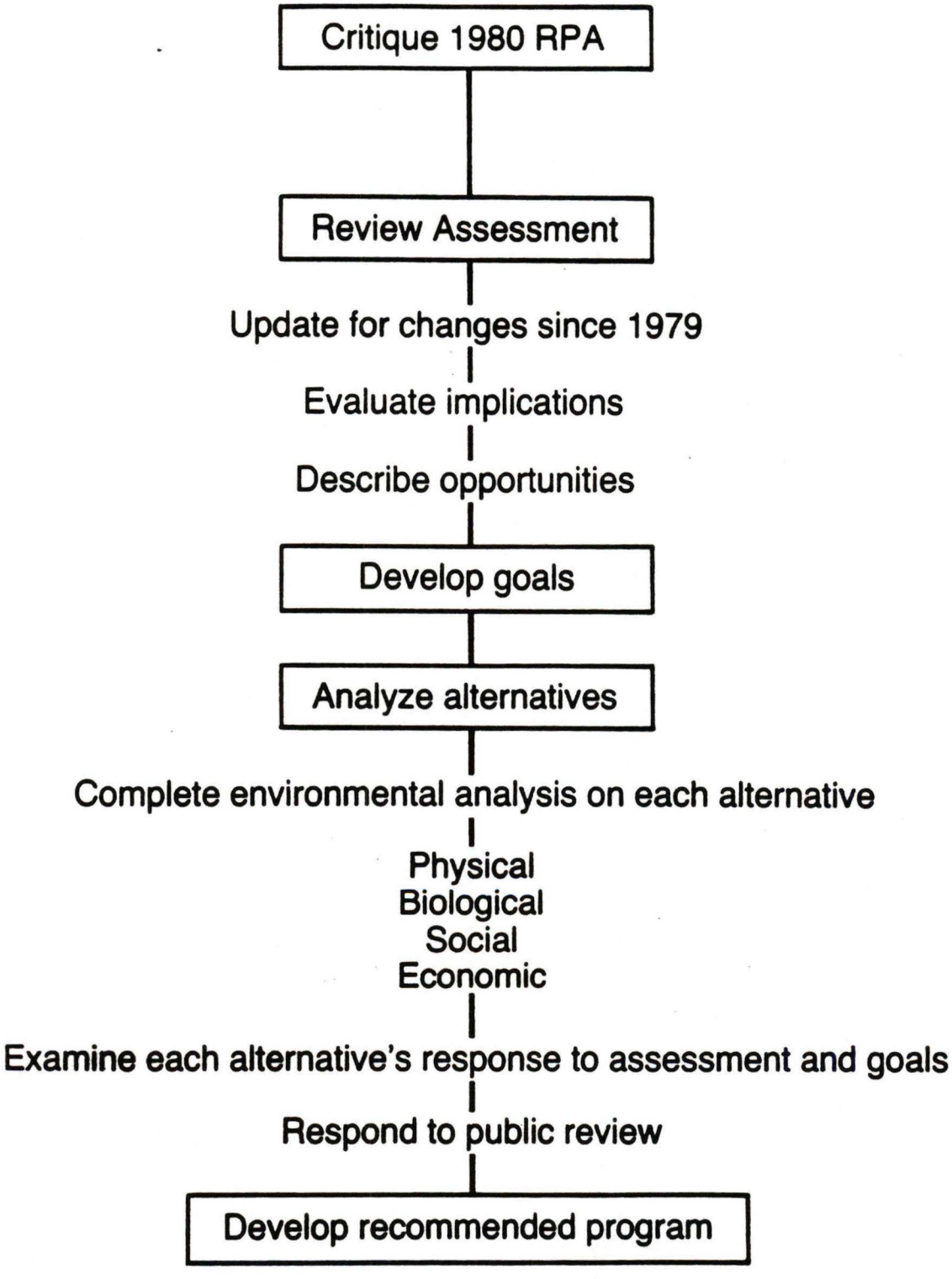
As described in the Forest Service Manual, the primary framework for developing a comprehensive research program in support of the Forest Service mission is defined by the Forest and Rangeland Renewable Resources Research Act of 1974, as amended (P.L. 93-378).[1] The Resources Planning Act (RPA) requires that the Secretary of Agriculture assess the status of the Nation's forest and range resources and recommend a program for their use. An Assessment is required every 10 years and a Recommended Program every 5 years.

In 1986 a third 5-year update was published by the Forest Service, giving guidance for both operational and research programs.[2] The 5-year RPA Program is a comprehensive assessment of the status of range and forest resources, a compilation of opportunities and problems, along with various program alternatives that can be put before Forest Service, Departmental, and congressional leadership for consideration and ultimate policy decision. This process involves wide consultation and collection of information from including managers, researchers, and users of forest and rangeland resources. (See Figure 1, 1985 RPA Program Development Process).[3]

It is difficult to imagine a more comprehensive effort to reach out to interested parties than that which accompanied the development of the third update of the RPA Program. Copies of the voluminous Draft

Figure 1.*

1985 RPA Program Development Process



*Source: Final Environmental Impact Statement, 1985-2030, Resources Planning Act Program, USDA, Forest Service, FS-403, Appendix B, p. B-3.

Environmental Impact Statement were distributed to nearly 12,000 individuals, interest groups, and government agencies. Comments were received from over 1,100 individuals and 200 organizations that included businesses, conservation and preservationist groups, recreation associations, professional societies, educational institutions, and Federal-State-Local government agencies. "Sister" Federal agencies that provided input included: from USDA-Extension Service, Science and Education, and Soil Conservation Service; from Department of the Interior-National Park Service, Fish and Wildlife Service, Bureau of Land Management, and Bureau of Indian Affairs, Army Corps of Engineers, Environmental Protection Agency, National Oceanic and Atmospheric Administration, Department of Energy, Tennessee Valley Authority, Department of Housing and Urban Development, and U.S. Department of State.[4]

This general policy framework is supplemented by more specific program planning which has its roots in each of the National Forests of the National Forest System. Every 15 years a plan is to be fully developed/updated on each of the National Forests. These plans, coming through the "operational" side of the Forest Service constitute a third, relatively long range input to the policy framework covering Forest Service research.

This framework is further supplemented on an annual basis by input from three different national advisory groups. The first is the Joint Council on Food and Agricultural Science (referred to as the Joint Council) which annually makes a report to the Secretary of Agriculture on priorities for research, extension, and higher education. The Council consists of 33 members representing leadership across the United States in these areas. Its purpose, working from similar bodies at the regional level, is to foster coordination and planning in both public and private research, extension, and teaching in the food and agricultural sciences.

A second advisory group is the National Agricultural Research and Extension Users Advisory Board. This Users Advisory Board (UAB) serves as a consultant body to the Secretary of Agriculture regarding National policies, priorities, and strategies for agricultural research and extension through an annual report. It also provides a report to the President and the Congress annually on the proposed budget for food and agricultural sciences. The 25 members of the UAB represent: producers of agricultural commodities, including forest and aquaculture products; consumers; farm suppliers and food and fiber processors; food marketing specialists; environmental specialists; and, rural development authorities.

As might be expected, the input of these two national committees tends to be somewhat general, with the exception of specific issues of timely importance, which touch on either the user or the research/extension/higher education community involved in agriculture.

The third major national advisory group is the Cooperative Forestry Research Advisory Council (CFRAC), which was established by the McIntire-Stennis Cooperative Forestry Research Act (P.L. 87-788). The Council's 16 members represent: forestry schools (4 members), industry (5 members), the Forest Service (1 member), State foresters (1 member), Agricultural Experiment Stations (2 members), and volunteer organizations of such diversity as the League of Women Voters or the National Wildlife Federation (2 members). The Council, administered by the Cooperative State Research Service in USDA, has a primary responsibility for the review and allocation (according to formula) of the Cooperative Forestry Research Program. It also provides a forum for the coordination of forestry research undertaken by the Forest Service, State forestry organizations, the 61 schools of forestry in the United States, and private industry. The research interests of the universities and private industry are put forward by the National Association of Professional Forestry Schools and Colleges, and the Forest Resources Research Committee of the National Forest Products Association/American Pulp Wood Association, respectively. The input from these three advisory groups, and particularly the latter one, CFRAC, can have an important influence on decisions within USDA and the Forest Service regarding any particular annual program.

Finally, there is the annual budget process by which more discrete program decisions are made involving personnel and financial resources. Although focused upon the upcoming fiscal year, each budget cycle inevitably includes at least three fiscal years--the current fiscal year, the immediate past fiscal year, and the upcoming fiscal year for which the budget is being planned and debated. Because of the increasingly lengthy deliberation within the budget process--both on the executive and legislative sides--it is not unusual for the consideration of the upcoming or "next" fiscal year planning to be telescoped into the following fiscal year, so that four budget years may be under consideration at any one time.

The following process is typical with respect to how the budget process is integrated with the research planning process. At the outset the Research Stations will know what is required (and what they want) with respect to the activities of their respective work units. The budget process will be initiated by a communication from the Office of Management and Budget to the Department of Agriculture indicating the resources which are expected to be available to the Department in the President's budget. The Department will take these guidelines, make preliminary decisions, and cascade budget guidance to the respective components, including the Forest Service. Forest Service Research will make preliminary decisions at the Washington Office level and provide guidance to the Research Stations. There will follow a series of iterative exercises and communications to "fit" the on-going multiyear research projects and/or programs, along with program modifications or redirections by the Chief and Deputy Chief, within the budget guidance parameters.

This completes the general description of the policy framework which overlays the Forest Service research planning and decision process. Next, it is important to describe the more specific process by which particular research projects or programs are developed, approved, and monitored.

The key actors in this process are: (1) the Research Work Unit (RWU) Research or Project Leader; (2) the Station Assistant Director for Research and the Station Director; and, (3) the Washington Office Research Staff Directors and their assistants. Although a research project can be initiated at any level, such as the Washington Office or the Station Director level, it is more likely that the process will be initiated by a senior scientist or Research Leader at the Research Station, working in conjunction with the Assistant Station Director for Research.

As noted in the Forest Service Manual, the Research Work Unit is the basic unit for planning and conducting research.

> A Research Work Unit is composed of one or more scientists and associated support personnel. There are three categories of Research Work Units:
>
> a. Research Work Units that are supported by one functional budget account.
>
> b. Pioneering Research Work Units supported by one functional budget account.
>
> c. Multifunctional Research Work Units supported by more than one functional budget account.[5]

Periodically (at least every five years) the Research Work Unit Leader, with the assistance of his scientists, develops an RWU description. This is "a concise summary of a Unit's mission, the problems to be solved through research and the reasons for their selection, the proposed research approach, planned accomplishments, and staffing needs."[6] This basic document goes from the Project or Program Leader to the Assistant Station Director for Research, through the Station Director to the appropriate Washington Office Staff Director for review and recommendation to the Deputy Chief for concurrence. It then returns to the Station Director for his final approval. This is the primary mechanism for research program decision.

An RWU description is revised whenever a mission, problem, or approach changes significantly during the term of a Research Work Unit.[7] That term typically is for a period of up to five years--this may be extended for the purpose of completing high priority work but it usually may be extended only once, and then for an additional year.[8]

Once an RWU description has been approved, the Project Leader, in conjunction with the Assistant Station Director for Research, and his scientists develop the problem analysis, and the identification and scheduling of the studies specified in the RWU description. This research problem analysis includes a definition of the problem, description of the proposed research and its importance to potential users, the benefits to be derived, the likelihood the research will result in a solution, a breakdown of the problem into study components and their expected research costs, and identification of cooperating personnel or facilities.[9] This research problem analysis receives approval from the Assistant Station Director for Research or the respective Program Manager. The scientist who actually performs the research is the one who will prepare the study plan.

The Station senior management--here either the Station Director or Assistant Director for Research--will be responsible for coordinating the Station's research program within the Station and with its counterpart Forest Service Regional Office and with Washington Office research staff. The same will be true for coordination between Research Stations. Interdepartmental and departmental coordination of research programs is handled by the Deputy Chief or by his respective staff officers-- commensurate with the level of the counterpart within USDA or other Federal agency.[10]

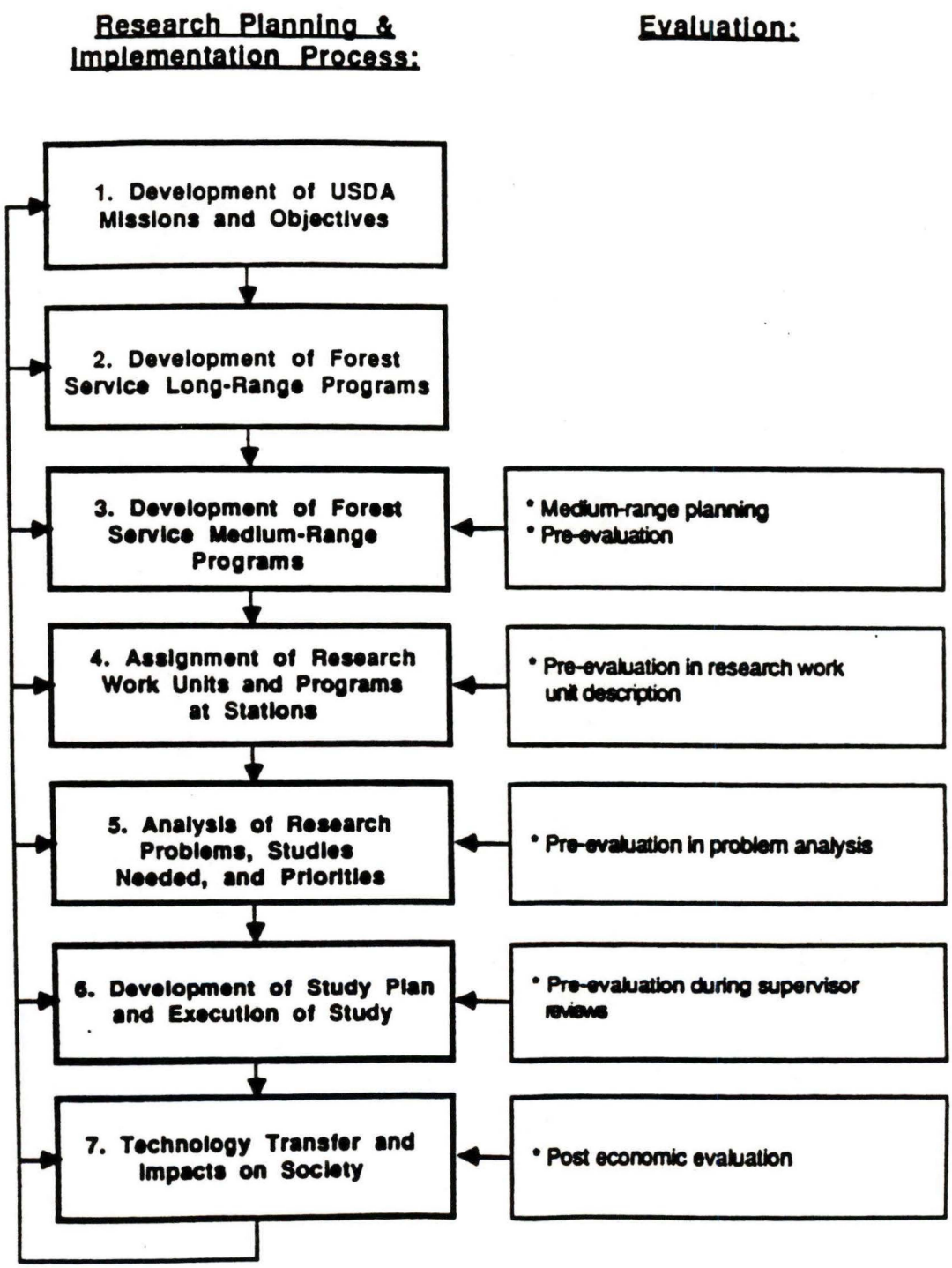
In the Washington Office, the heart of the program decision process resides with the Research Staff Directors. There is a Staff Director in each of the following areas of research interest: Timber Management Research, Forest Environment Research, Forest Fire and Atmospheric Sciences Research, Forest Insect and Disease Research, Forest Products and Harvesting Research, Forest Inventory and Economics Research, and International Forestry. These Directors and their supporting staff have the responsibility for providing advice to the Deputy Chief (Research) and to the Research Station Directors on program development, budgeting, technical support, and oversight for Forest Service research programs within their respective areas.[11]

For a graphic presentation of the sequence and the elements involved in research planning and implementation within the Forest Service see Figure 2, The Research Planning Process and Evaluation Process in the Forest Service.

In summary, the Research Program of the Forest Service is an outgrowth of the development of USDA missions and objectives and the Forest Service long range planning programs. These are influenced by legislation and Presidential direction, but the formal and highly detailed RPA process and its updating provides the bulk of the structure for decision. Several national advisory groups provide annual input to the development of both long range programs and annual programs. It should be noted that the medium range planning process (3 to 5 years) is a relatively new development, just now being put into

Figure 2.*

The Research Planning Process and Evaluation Process in the Forest Service



*Source: Forest Service Manual, Series 4000 (Research), Interim Directive No. 4, 4071, Research Program Formulation, April 1987.

place, which is designed to bridge the gap between the RPA 5-year program and the annual budget process. As noted earlier, the RWU at the Research Station is the heart of the system. It is at this level that many problems and needs will be identified and an initial assessment of priority defined. These proposals are then reviewed at the Station level, coordinated with others working in that research area and potential users represented through the Regional Office, then forwarded to the Washington Office for review and approval. Once a program is accepted, it is the RWU that will develop the study plan and actually execute the research. From time to time the Washington Office will be the instigator of a new research program. However, the RWU, as the principal technical resource at the Research Station, is in a position (with the help of the Assistant Station Director for Research) to make early identification of user needs through contact with a Regional Office, National Forest, and adjacent Research Stations.

2. Informal Influences

There are at least four informal factors which have a noticeable influence on the formal process in actual operation. These are: (1) the degree of autonomy of the Forest Service Research Stations; (2) the innovative nature of research leadership--either in the Research Stations or the Washington Office; (3) the capability within the National Forest System (NFS) for local "problem-solving"; and, (4) the ad hoc influence of user's or clients at the local level via political contacts outside the formal system.

An important factor of informal influence upon the research decision process is the degree of autonomy among the Research Stations in the Forest Service, given the relatively strict hierarchy within the organization as a whole. Other elements of the Service, particularly the National Forest System, tend to follow a pattern of a quasi-military nature. Entry to the Service is at the lowest level with little lateral entry for professionals, and a planned program of rotation through a variety of job experiences. In contrast, researchers may spend 15 or 20 years at a single Research Station without moving. Senior research managers may come from outside the Forest Service, such as from university research or administration or from similar or related positions in other Federal agencies (such as the Park Service, the Fish and Wildlife Service or the Environmental Protection Agency). These kinds of practices, coupled with the nature of research itself, tend to reinforce a degree of autonomy among the Research Stations not typical of the Service as a whole. The Research Staff Directors in the Washington Office clearly are advisors to the Deputy Chief rather than line program managers with formal authority over their respective areas of research in the Research Sations.

Because of this autonomy, the nature of the research advice and decision input from the various Research Stations represents

considerable heterogeniety. For example, in the process of developing a new or revised charter for an RWU, one Research Station may do this almost exclusively within the ambit of advice from colleagues and others within the Research Station, supplemented by some consultation with the requisite Regional Office. In others there may be extensive attempts via public meetings, mail and telephone surveys, and other means to tap concerns of potential users and cooperators to identify research needs and priorities. Because of this potential for wide variance in the process, Washington Office Research Staff Directors must interpolate such recommendations, according to their knowledge and understanding of the respective "cultures" in the initiating Research Station.

A second factor is the innovative nature of the research leadership; this can be exercised at either the Research Station or Washington Office levels, but depends upon the individual scientist in the recommending and/or reviewing position. For example, one Washington Office specialist may be more persistent than another in establishing professional linkages with colleagues outside of the regular Forest Service network in order to have the broadest knowledge possible of developments within a particular scientific field. This could include extensive scanning of scientific journals, using electronic means to access bibliographic material, and attendance at professional meetings. None of this is discouraged, but within the context of limited time and resources, will take special effort and interest. Such persons may be the source of more project initiatives than might be another colleague.

By the same token, similar opportunities for individual initiative abound in the Research Stations. It can be abetted by distance from Washington and typical bureaucratic practices. This provides the scientific entrepreneur with opportunities for developing cooperative relationships with other agencies, universities, or even private organizations to supplement and further his/her research interests. A sample of Research Station documents such as RWU descriptions--even scientist position descriptions--reveals that there is substantial latitude for "fitting" researchers' primary interests into a package that will satisfy the broader policy and program guidance requirements issued by the Washington Office. Even in the area of resource planning and use, the Research Stations have substantial latitude. For example, one Station may choose to "protect" its personnel complement by dedicating most of its operating funds to in-house salary support. Another station, seeking greater research flexibility, may choose to reduce its full time equivalents over a period of time in order to provide additional funds for cooperative, grant or contract research where skills more in line with perceived research needs may be made available.

A third factor, as described by officials within Forest Service Research, is the increasing capability within the National Forest System for sophisticated, technology-based "problem-solving."

Observers note that in the course of the past two decades, the National Forest System has been required to dedicate more trained personnel to analyses in support of environmental requirements. This and the technical input required by the increasingly more sophisticated and data-demanding planning processes, coupled with "on location" capability for computer operations and systems integration--all translate to greater technical staffing in NFS. Such demands have been met with a shift in the type of people being hired in the National Forest System--to include more individuals who are technically qualified in the biological, systems, computer, and social sciences. This has given the National Forest System a much stronger local capability in the technical solution of problems that, in the past, might have been referred to research.

Finally, there is the ad hoc influence of local or regional users/clients, or other parties at interest who work through a political communication process outside the Forest Service system. This is most apparent in the congressional "concern" expressed when Forest Service leadership is attempting to close or reduce activity at a particular facility, or to conclude a particular research project. It also surfaces in earmarked research projects inserted during the appropriations process by a Member of Congress. Typically such "end runs" are achieved by individuals who have a user or participant interest in the particular question at hand, combined with the capability for obtaining a favorable hearing by the interested Member. Such ad hoc activities are not unpredictable, but they are disruptive because they occur outside the system and the success of such efforts cannot always be determined before the fact.

B. Effecting Program Change

The term "change" here refers only to a program shift that is of at least regional or national consequence in scope. Based principally on the written materials, the following three observations are made regarding the possibility of effecting program change within the Forest Service's system for research planning and decision.

First, the breadth and continuity of research conducted by the Forest Service generally precludes the need for changes outside the annual budget cycle. It would be very unusual that a circumstance would occur which would require a substantial shift or dedication of resources toward a new research problem, and require that change to be effected in less than six months to a year. There are so many opportunities for significant input into this research decision process, from the very long term (such as the RPA Assessments) to the annual budget cycle, that it is difficult to conceive of a circumstance

in which these means would be inadequate either to identify or to meet some rising opportunity or need. This is not to say that such accommodation could be made without difficulty or substantial disruption to other programs. But there certainly appears to be adequate opportunity for timely research program change to be accomplished in an orderly manner.

Second, The installation of a mid-range planning system (3-5 years) now being instituted should make a substantial contribution to bridging the otherwise apparent gap between the annual budget process and the RPA Program (5-year) or Assessment (10-year) planning processes. As mid-range planning is successfully incorporated into the Forest Service research system, it should provide for a better accommodation between immediate, near term needs of a high priority and the research continuity necessary to retain scientific capability and to address long term research issues of substantial importance.

New research program starts appear to be initiated most often by the Washington Office, using newly available or reassigned funds. This is to be expected if the Washington Office staff is fully performing its function. It is in the best position to have a broad view of the respective fields of science and technology, as well as easier access to points of influence within the Department of Agriculture that might provide support for shifting priorities or new programs. The staff has the same advantage with respect to similar opportunities provided through liaison with headquarters officials in sister agencies outside of the Department, and with influential congressional staff. However, in exploiting this advantage of perspective and location, Washington Office staff need also to be sensitive to the needs and capabilities of their research colleagues in the Research Stations.

In summary, their appears to be ample provision within the formal research planning and decision process of the Forest Service to undertake program change in a timely manner. The extent to which the system has either succeeded or failed in meeting the practical tests of being able to accommodate timely change remains to be answered in Task 3.

C. Comparison With Other Research Organizations

At this stage of the MCRG study, comparison was limited to four other Federal agencies, based upon the research proposal as well as the possible potential for analogous circumstances from which the Forest Service might draw useful lessons. It will be noted that the comparison leads to a similar conclusion here as was reached in an earlier Forest Service study that there are considerably more differences than similarities with respect to key elements.[12] The four research organizations with which the comparison was made are: the Agricultural Research Service, the Fish and Wildlife Service, the National Institutes of Health, and the National Aeronautics and Space Administration.

1. The Agricultural Research Service (ARS)

There are three principal similarities providing some "commonality" between Forest Service research and the Agricultural Research Service. The first is that both deal with a broad, widely dispersed clientele of in-house, other Federal agency, State/local, university, private, and industrial users. The second is that they have similar research interests, although representing different balances, in the biological and natural resource areas. Third, they share common USDA administration and managerial processes from that level. They are under the same policy umbrella for the Department, and receive policy advice from such national advisory groups as the Joint Council on Food and Agricultural Science and the National Agricultural Research and Extension Users Advisory Board.

In spite of being "sister" research agencies, there are a substantial number of important differences. First, ARS is a stand-alone research agency. Although it serves many users (some within USDA), it is a research agency per se and not an organizational element within a general operating agency. Second, in contrast to Forest Service, the primary clients of research are outside the formal structure of the Department of Agriculture. Third, the ARS is one of several principal USDA organizations directly under the leadership of an Assistant Secretary of Agriculture who is responsible for the broad areas of science and education. Fourth, the ARS management and decision process is more centralized within the Washington office (National Program Staff) than is the case of research in the Forest Service.

Fifth, and of substantial importance, is the fact that ARS obtains its appropriations through a different congressional subcommittee; here the Subcommittee on Rural Development, Agriculture, and Related Agencies in the House of Representatives where the Chairman of the subcommittee also is Chairman of the full committee; and the Subcommittee on Agriculture, Rural Development, and Related Agencies in the Senate where the ranking majority member of the subcommittee is also Chairman of the full committee on appropriations. In contrast, the Forest Service obtains its appropriations from the Subcommittee on Interior and Related Agencies in the House of Representatives and from the Subcommittee on Interior and Related Agencies in the Senate. Needless to say, the Forest Service necessarily suffers from some departmental neglect in the congressional appropriations process, if only because the Department's principal point of contact will be with its respective agricultural appropriations subcommittees.

Sixth, there is a considerable difference in the nature of the emphasis on the principal areas of research interest. ARS research focus is inclined less to applied research and development than is the case in the Forest Service, and ARS research tends to deal more with

commodities and is less environmentally-oriented than is true in the Forest Service. In this latter case it is principally a matter of degree, but it still is pronounced in terms of research focus.

The ARS program decision mechanisms are similar in form and style of operation to those within the Forest Service--at least partly because this system grows out of the USDA's extensive network for input by users and other interested participants. However, even here, there are some primary differences. For example, the National Program Staff has substantially greater influence and authority over the direction of ARS research than is true of their counterparts in Forest Service research. Second, ARS's "in-house" USDA users represent a much smaller proportion of their research clientele, therefore, yield less influence on the ARS research agenda. Finally, the ARS program decision mechanism benefits substantially from the leadership of an Assistant Secretary of Agriculture who is in a strong position to champion research within USDA and up through the chain in the congressional appropriations process.

2. Fish and Wildlife Service

In some respects, it seems that there are more areas of comparability between the Fish and Wildlife Service and the Forest Service research organization than there are between the Forest Service and its sister organization, ARS. For example, if one limits the area of research focus to wildlife and wildlife management, there are very similar and overlapping areas of interest between the Fish and Wildlife Service and the Forest Service. The primary exception here is that the Fish and Wildlife Service concentrates on species across the totallity of the United States, whereas the Forest Service necessarily concentrates on location-specific species--i.e. those which are located in its National Forests or protected rangelands. Second, the initiation and conduct of specific research projects tends to be largely decentralized. In the case of the Fish and Wildlife Service this will occur at their Research Field Stations or at wildlife refuges. The main difference here is that there is line management authority from the Washington office level in the Fish and Wildlife Service, not similarly exercised within the Forest Service for the research function. Third, like the case of the National Forest System, local Fish and Wildlife refuges undertake "problem-solving" studies, essentially on their own with dollars that are outside the formal research program. Fourth, the research organization within the Fish and Wildlife Service serves principally an in-house clientele, although its research also is carefully coordinated and used by State Game and Fish Departments. Fifth, both Fish and Wildlife Service and the Forest Service Research organizations are served by the same appropriations subcommittees in both the House of Representatives and the U.S. Senate.

Key differences reside in the nature of the research focus and the general manner of departmental administration. Although both research

organizations are concerned with environmental and conservation issues, there clearly is a greater concern with commodity research within the Forest Service than is true in the Fish and Wildlife Service. Second, the "culture" of the Department of the Interior is substantially different in its administrative management style from that of USDA. There are, however, commonalities at the Assistant Secretary level since both the Forest Service and the Fish and Wildlife Service fall within the aegis of an Assistant Secretary who has primarily program and operations concerns. In the case of Interior the Assistant Secretary is responsible for both the National Park Service and the Fish and Wildlife Service.

The program decision mechanism within the Fish and Wildlife Service is similar to that in the Forest Service in that research project proposals most often are initiated in the Field Research Stations and must fit into the Departmental and Service-wide priorities. However, in the Fish and Wildlife Service the decisions with respect to specific projects is a line management decision made by the Washington office equivalent of the Deputy Chief Forester. Senior research managers in the Fish and Wildlife Service complain about the same kind of difficulties or obstacles as do their counterparts in the Forest Service.

3. National Institutes of Health

The National Institutes of Health share several similarities with the Forest Service Research organization. First, its primary interest in research is in the biological sciences, even though this is directed at human health. Second, NIH makes extensive use of advisory groups in its research decision and policy process. These groups typically are made up of users, system participants (such as researchers, university representatives, and others) and members representing the general public interest. Third, they share a similar time horizon with respect to their principal unit of research. In NIH research activities, the research study typically has a time period of from three to five years as is true of the RWU within the Forest Service. Finally, NIH, like the Forest Service, must deal with substantial variation in of departmental support of its programs before congressional authorization and appropriations committees. There tends to be stronger positive interest in the Congress--at times--than there is at the departmental and Presidential levels.

There are very important differences between NIH and the Forest Service Research organization. First, NIH is a stand-alone research agency, without operational responsibilities. Second, its clientele is almost exclusively external to the department in which it is housed. Third, both the agency and many of its research programs have very high public visibility, and the agency typically enjoys relatively high public and congressional support. Fourth, the vast bulk (approximately 80 percent) of the NIH research and development dollars are extramural-oriented. Fifth, there generally is less emphasis on applied research

and development in terms of the total balance of the NIH program than is true within the Forest Service.

In like fashion, the NIH program decision process has both similarities and substantial differences when compared to that of the Forest Service. There are three characteristics of the NIH program decision mechanism that are particularly pronounced. First, is their primary, almost exclusive, use of advisory committees for policy guidance. Second, and closely linked with the use of these policy advisory committees, is the use of peer review committees for selection of specific projects. There are some exceptions to this, and particularly where NIH undertakes a development program; however, there typically is some type of review mechanism which involves outside and peer representation. Third, the clientele-political linkages and mechanisms tend to be highly supportive of NIH, and these support organizations are not often in substantial conflict. In contrast, the sometimes conflicting or apparently conflicting goals of productivity and environmental protection which commonly reside within the Forest Service mission also may be reflected (in particular instances) in substantially different viewpoints among the potential supporters of the Forest Service Program--industrial and other forest product users versus environmental organizations.

4. National Aeronautics and Space Administration

In spite of obvious differences, there are some important similarities between the Forest Service Research organization and NASA. For example, the primary clientele of NASA is in-house--either within NASA (which is the principal clientele) or other agencies of the Federal government, particularly the Department of Defense. Second, both NASA and the Forest Service focus on all aspects of research from the most basic to engineering development just short of production, with the primary focus upon applied research and development. Third, both organizations provide substantial autonomy to their field research stations. Fourth, each is in that very elite group considered to be the best managed Federal agencies.

The differences tend to be a bit more pronounced. NASA is a stand-alone, independent agency with some operational responsibility, but has its primary mission as research and development. Second, it is an extremely high visibility agency (as is true of its program) that often has very strong public interest and support and generally has received favorable political support in the Congress. Third, the research budget is more than 70 times as large as the Forest Service research budget. Fourth, the research is primarily in the physical sciences and engineering. Fifth, most of the research and development is conducted under contract or grant outside the agency. Sixth, the research field stations are much larger than their counterparts within the Forest Service--any one of NASA's Field Centers is larger than the entire Forest Service Research organization.

Like other Federal research organizations NASA shares some similarities and also has some substantial differences in its program decision mechanisms. NASA makes limited use of advisory groups but the basic policy and program decisions tend to be made by NASA Headquarters in conjunction with Presidential and congressional leadership. Major initiatives typically come from the Headquarters Program Offices or from the senior Field Center management. Most other project proposals originate at the Field Centers and are designed to "mesh" with agency goals and broad program objectives--similar to the Forest Service system. The program decision process is highly structured to stimulate research proposals from the field, within a structure of program goals and priorities. This system is designated as the Research and Technology Objective and Plan (RTOP). These RTOPs support technology development/maintenance and flight programs which encompass a wide variety of technical areas. Substantial program changes tend to be slow, and are often made within the RTOP and 5-year planning construct. Quick reaction to unforeseen problems--e.g. the Apollo fire and the Shuttle accident--are accomplished only with substantial disruption in those programs, and, often in RTOP activity areas. For such emergencies (as well as similar but not so dramatic flight failures) NASA often pulls together technical experts from throughout its system (which may mean contractors as well) to form "Tiger Teams" which thoroughly review the problem with an eye toward identifying all causes of failure and extracting as much understanding as possible.

D. Observations and Conclusions

It should be noted that, at this point in the study, there has been no exploration of "research" or development activities conducted within the National Forest System, but outside the formal research funding and decision system. Also, this characterization of the formal research planning and decision process in the Forest Service has yet to be tested by more systematic review by Forest Service research officials and through more extensive interviews with Washington Office officials and with research managers in the field. Given those constraints, the following tentative conclusions are put forward.

First, nothing in the structure of the planning and decision process appears to present a particular or striking obstacle to effective program management or to the appropriate and timely accommodation of program change. There is one clear exception, and it applies to the Forest Service in general. That is the limitation (particularly applicable to research programs) of having an annual one-year budget authority. The research planning and decision process could be substantially enhanced if the Forest Service had "no year money" for its research program.

Second, similar research organizations in other Federal agencies do not demonstrate a "superior" program development, decision, or change system. However, other Federal R&D organizations follow some

practices which may be useful to the Forest Service in other aspects of research management. They are not relevant to this particular discussion, but will be discussed with the COTR, and may be addressed in a later report.

The above characterization of the Forest Service research planning and decision process and its management of program change will be "tested" by more extensive interviews with Forest Service research and other officials, revised, and "tested" in a substantive fashion through several mini-case examples of research projects which offer the opportunity to explore the system's effectiveness to accommodate needed program change--to be reported in Task III.

Task 2 Report Footnotes

1. Forest Service Manual (hereinafter, FSM) 4070.1 Authority as amended 11/87.

2. Final Environmental Impact Statement, 1985-2030, Resources Planning Act Program, USDA, Forest Service, FS-403, October 1986

3. Ibid., page B-3.

4. Ibid., page M-4, pp. 6-1 to 6-11.

5. FSM 4070.56 "Research Work Unit."

6. FSM 4072.11

7. FSM 4072.15b

8. FSM 4072.15c

9. FSM 4072.2 and 4072.21

10. FSM 4071.3 et seq.

11. FSM 4070.416

12. See: Criteria for Deciding About Forestry Research Programs, UDSA, General Technical Report WO-29, July 1981 pp. 7-8.

Appendix F

STUDY PROJECT:
ASSESSMENT OF THE COMPETITIVENESS OF FOREST SERVICE RESEARCH

Task III Report
Effectiveness of Program Change Mechanisms In Forest Service Research

March 31, 1988

Task III: Effectiveness Of Program Change Mechanisms In Forest Service Research

This analysis of the effectiveness of the program change mechanisms in Forest Service Research is presented in five parts. The first summarizes the extent to which those observations and conclusions about the Forest Service research change mechanism as characterized in the Task II report have been confirmed or modified. Part II judges the relative performance of the program change mechanisms in terms of six criteria for effectiveness. Part III identifies and comments upon those factors which either facilitate responsiveness to research needs or appear to be obstacles to such responsiveness. Part IV summarizes the results of the three mini-cases which were developed to provide a further context in judging the effectiveness of program change. Finally, part V summarizes preliminary conclusions and observations about the effectiveness of the program change mechanism in Forest Service Research.

I. Testing the Conclusions About The Character of Program Change Management in Forest Service Research.

The Task II report, "The Management of Program Change in the Forest Service," January 15, 1988, concluded with three general characterizations of that system:

> (1) generally, there is no need for changes outside the regular planning and budget cycle because there is sufficient opportunity on a timely basis to accommodate change within the processes currently available;
>
> (2) the new mid-range planning process clearly facilitates more effective responsiveness to the need for change; and
>
> (3) new starts (at least in recent years) most often are initiated from the Washington Office with new dollars or reallocation among programs--the latter obviously being "more difficult."

Basically, these observations were confirmed in the subsequent interviews at the Forest Experiment Stations (Pacific Southwest, Rocky Mountain, Northeastern, and Southeastern) and in Washington Office staff interviews with senior managers from Forest Service Research, State and Private Forestry, and the National Forest System. The interviews did reveal some differences of opinion with respect to how the system was structured and operated. In seeking responses to the issue of what actually constituted the system, a one-page summary was presented to those interviewed in the Forest Experiment Stations for their comment and criticism (see synopsis below).

A Synopsis of the Forest Service's Research Planning and Decision Process

There are three national advisory groups that provide policy suggestions for the Secretary of Agriculture that will affect the direction of Forest Service programs. They are the Joint Council on Forest and Agricultural Science, the National Agricultural Research and Extension Users Advisory Board, and the Cooperative Forestry Research Advisory Council. Typically, advice or recommendations from these groups is general and long-term, supporting the principal interests and direction of current and future plans. Occasionally, these groups will suggest a re-direction of emphasis or resources relating to an annual budget. Their advice cannot be ignored, but rarely results in dramatic or short-term changes.

The formal planning structure has two long-term elements: (1) the 15-year plan for each National Forest and (2) the 10-year RPA Assessment. Although each is independently cycled, they are closely related in that the now detailed National Forest plans will be guided by the most recent RPA Assessment issues, and the 5-year RPA Recommended Program. Each of these three involves substantial outreach to cooperating and interested parties so that most concerns should be included in one or more of these processes. Both the National Forest plans and the RPA Program provide sufficient detail so that research program guidance (and decisions) can be developed at the Washington Office, Research Experiment Station, and Regional Office levels. They provide a program policy backdrop against which to undertake the recently initiated mid-range research planning and the RWU charter determination as well as decisions regarding resource allocation in the annual budget process.

The key elements in detailed planning and decision-making regarding Forest Service research are the RWU descriptions and the annual budget exercise. Each involves a 3-5 year time horizon, with annual updates and a nearly continuous iteration of information - revision - decision. RWU charters are determined on the basis of: (1) program direction and resource allocation from Forest Service headquarters, (2) user needs and priorities, and (3) research interest and capabilities at the Stations. The actual conduct of research will be affected by resource allocation decisions made generally at the Washington Office, and specifically at the Research Station. Relative success at attracting funds from outside the research budget (e.g., from the National Forest System, other agencies or non-government organizations) will affect RWU resource allocation. Research Station management has substantial leeway in allocating resources to the means for accomplishing research agenda. Station management and research leaders are limited by: resource ceilings, priority research programs, procurement or personnel regulations, and maintaining long-term scientific capability.

* * * * *

Few comments were received in the interviews about the role of the National Advisory Groups in terms of policy advice and suggestions. Several deans of forestry schools who have participated in such advisory groups downplayed any particular or direct affects upon FSR programs. There was some difference of opinion regarding how the research needs portion of the RPA Assessment fits into the Forest Service Research's planning process. Some acknowledged that the RPA Assessment provided at least a general policy baseline. On the other hand, others commented to the effect that the RPA Assessment was independent and outside of Forest Research planning. Others indicated that they thought there should be a closer tie between the kinds of research needs identified in the RPA Assessment and the actual planning that takes place in the mid-range plan and in annual budgeting for Forestry Research. Several respondents wanted to clarify what constitutes a "new start." Those which are considered to be local in nature clearly are a responsibility of the Research Station management, and may fit into broader regional or national program goals. On the other hand, new areas of emphasis that are either national or regional in scope tend to be limited to those initiatives which have cleared a Washington Office review and approval process and most frequently are initiated at that level. Experiment Station scientists noted that "national" program emphases often were the result of Experiment Station concern or prodding.

II. Performance As Judged By Criteria of Effectiveness For Program Change.

MCRG, in consultation with the COTR, arrived at six criteria to be used in judging the relative effectiveness of Forest Service Research program change mechanisms. These six were: (1) degree of program flexibility identified principally in the percentage of resources that are "locked in"; (2) key research opportunities actually undertaken; (3) relative ease of program change; (4) the relative "willingness" to change (in the light of the institutional inertia and the nature of Forest Service research); (5) expectations of senior leadership and users; and, (6) integration with other research.

1. Degree of Program Flexibility

The principal question here was what percentage of the resources available to an Experiment Station are "locked in" to continuing salaries? The assumption is that, to the extent that these resources are tied up in continuing personnel costs of individuals already at the station, they are not available for grant, contract, equipment, or similar uses to meet program changes. This does not mean that persons already at a Station cannot be redirected in terms of their research objectives. What it does recognize is that having resources available other than salaries generally provides a higher degree of flexibility. A less obvious source limiting flexibility is earmarking particular projects by Congress. This may be invited by local lobbying.

The interviews provided a surprising result. Senior managers in the four Experiment Stations visited, indicated that they had "flexible" resources, not tied to personnel costs ranging from 25-40% of their total Station budgets. Although this represents considerable variation among the Stations, it also illustrates substantial flexibility for relatively short-term changes in the event that there is a need to re-apply resources. Typically, senior managers indicated that they would go the grant or contract route most frequently to deal with research needs where results were required within two years or less.

2. Key Opportunities Actually Undertaken

Discussions with Washington Office staff directors in the Forest Service Research system and the National Forest System, and in State and Private Forestry revealed no substantial opportunities that were being "missed" in terms of nation-wide Forest Service research needs. All had agendas or lists of activities that could not be included in the particular budget year simply because of the unavailability of resources. However, there was little evidence of key opportunities that were being passed up in terms of not being funded currently or planned.

In August 1987 a report, "Research Needs In Forest Service Plans," was prepared by a nine member evaluation team headed by Dr. Eldon Ross, Associate Deputy Chief for Research. This report (dated August 24, 1987) identified research needs that were coming from the various Regions of the Forest Service taken from National Forest plans, and classified according to "current status." The data reported were applied to all needs submitted in those forest plans and were as follows:

Current Status	Percent of Total
(1) Needs resolved with current technology	22%
(2) Needs currently being studied	42%
(3) Needs for which research is planned	23%
(4) Needs for which research is not planned	13%

This report suggests that only a small percentage of all research needs submitted in National Forest plans is not being addressed in some fashion. However, the process of identifying research needs had not yet been completed in the Southeastern and Southern Experiment Stations. That report which was released in January 1988 provided substantially different data for those two research stations. That report revealed that of all the needs submitted, 44 percent represented needs for which no research was planned.

It must be emphasized that both the study and the results from the Southeastern and Southern stations represent a review of all needs submitted in that particular planning process--not just key opportunities. However, there seems to be some difference of perception regarding the degree to which research needs are being addressed. Since this particular exercise addressed locally-developed research needs, it would be unfair to characterize current responsiveness as inadequate with respect to the question of key opportunities. They probably should be viewed more from the regional and national viewpoint than from solely a National Forest perspective. On the other hand, there obviously are problems of substantial importance to a particular forest which need attention in some fashion--either from Forest Service Research or from other sources of technical data.

3. Ease of Program Change

This criterion is assessed on the basis of the number of decision levels or points of consensus that must be encountered in attempting a program change. The formal process described in Task II reveals that this is not an arduous task. With the institution of the "pilot program" which permits a Station director to have considerable local autonomy in the reallocation of resources, changes at the local level can be accomplished with considerable dispatch. Where program change requires regional or national consideration, the process obviously is more demanding and involves more points of decision. Consistent with Forest Service philosophy, there is the strong tendency to work for some type of consensus with senior research leadership (to include the leadership of the Forest Experiment Stations) before instituting a new program. Research initiatives that are essentially political mandates by the Administration and the Congress involve primarily questions of implementation rather than basic decision regarding program change. In cases where the "new money" is acquired through redirecting other programs, the relative ease will depend upon whether these programs are being supported out of the reallocation of Forest Service research funds or from funds reprogrammed from other Forest Service groups, such as the National Forest System. In any case, it is the reallocation decisions which are the most difficult to process because of the larger number of people involved in developing the necessary consensus. Although program change is not automatic, the process cannot be considered to be universally so cumbersome as to seriously impair effectiveness for program change.

4. Relative Willingness To Change

Willingness to change is a complex element with a number of dimensions. One of the important dimensions is the nature of Forest Service research, which unlike most other agencies, consists of longer term activities which may require decades of data collection and monitoring. This means that a proportionally higher percentage of Forest Service research is going to be tied up over the long term than is the case with other research organizations. A closely related factor is that of institutional inertia. The relatively conservative nature of the Forest Service as an organization

has a tempering effect upon any predisposition to change process or procedure. This will not always affect substantive program shifts, but it does put more of a burden upon the justification for change. This conservative nature of the whole forestry complex (including users) makes innovation through research more demanding on those who would press for it. It is not just a matter of a reticence on the part of researchers to shift focus; the general reluctance to change permeates the whole community and is reflected in the fact that the forestry industry has a strong tendency (compared to other industries) to underfund research in general. Of all the criteria, this one is the most difficult to judge in terms of how it operates within the Forest Service with respect to effectiveness of program change. Various aspects which affect the responsiveness of Forest Service research regarding this particular criterion will be discussed under the context of that topic. In general, however, there is a reluctance to change which is apparent at all levels within the organization.

5. Expectations of Senior Leadership and Users

Interviews with the top management of the Forest Service, with users outside the agency, and with inside users (National Forest System and State and Private Forestry) revealed a surprising degree of satisfaction with the ability of Forest Service Research to respond to their respective needs/expectations. As an organization, Forest Service Research is perceived to be as responsive as one can reasonably expect given limitations of funding and other resources. There were some users who voiced dissatisfaction, but that source of dissatisfaction seems to rest primarily with particular individuals and their responsiveness, rather than to the system or institution as a whole. The primary point of possible exception is the viewpoint expressed by many external users to the effect that the leadership in the Forest Service is not as effective as it could or should be with respect to obtaining needed resources to expand current research activities and to undertake new initiatives. There has been a similar concern voiced throughout various levels of the research organization itself. This particular issue will not be pursued at this point, but will be addressed in greater detail in the Task VI report. Generally, it may be said that the system's process for program change is viewed positively by both the senior leadership within the Forest Service and the user communities--whether internal or external to the Forest Service.

6. Integration With Other Research

Discussions with outside users, including representatives of industry associations, professional groups, and academic institutions revealed considerable cooperative efforts in forestry research. There also is strong evidence of cooperation with other Federal agencies such as the National Park Service, the Fish and Wildlife Service, the Bureau of Land Management, the Soil Conservation Service, the Environmental Protection Agency, and similar sister" natural resource agencies. In addition, the RPA process provides substantial opportunity for coordination and examination of current research programs in conjunction with the exploration of future needs. On the other hand there was little evidence from these wide ranging discussions which

demonstrated any significant "reaching out" to the broader biological research community beyond the traditional boundaries of the forestry research community. In fact, several very senior observers of the scientific establishment within both Agriculture and the Washington scientific community commented to the effect that, in recent years, the Forest Service Research leadership has not made significant attempts to facilitate more extensive liaison with the biological research community in general and the Washington scientific establishment in particular. The information available is not sufficient to identify specific results from this; however, it may have some relevance to the comparatively slow progress that Forest Service Research has experienced in facilitating more aggressive initiatives in the area of biotechnology.

In summary, the effectiveness of program change mechanisms in Forest Service Research, as judged by the above six criteria, must be rated as good to excellent. The most noticeable deficiency appears to be a relative unwillingness to change, which has its roots in institutional factors as well as the long term nature of much of Forest Service research. Those institutional factors will be discussed next.

III. Facilitating Factors and Obstacles to Responsiveness

To whom should Forest Service Research be responsive? One would think that this is self evident: Forest Service Research should be responsive to its users, and to the senior management of the Forest Service which will be responsive to the broad user community. We found no real disagreement with this. The bind comes when one tries to define what constitutes Forest Service Research's "user community." And this relates directly to the question of what constitutes the Forest Service Research mission. We found a number of different perspectives about this--and this, in turn, tends to dissipate energies needed to compete for research resources. (This issue will be dealt with in connection with the competitiveness of Forest Service research in the Task V report.)

The most common consensus regarding the Forest Service research mission centers upon one or both of two perceptions: (1) Forest Service research is long term research directed at the broad natural resources community, with forestry as its central concern; and (2) Forest Service research is to serve, principally, but not exclusively, the needs of the National Forest System.

These are not mutually exclusive; however, using one or the other as a main focus can result in substantially different approaches to a research program and its support. Issues growing from these perceptions include the relative importance of basic vis-a-vis applied research, criteria used for the system of "rewards," the "community" with which scientists identify themselves, etc. Forest Service Research truly needs some broad "vision" around which consensus can be developed and energies concentrated in order to have a more effective research system and to attract needed resources.

1. Facilitating Factors

Three factors which facilitate the effectiveness of program change were

revealed by the series of interviews: (1) recent management initiatives to provide better linkages and flexibility for decision making such as the institution of the recent mid-range planning and the Chief's pilot program; (2) the recognition among Forest Service scientists that meeting user needs gives the research system essential external political support; and (3) the positive establishment of networks for seeking out and exchanging information by Forest Service research personnel with universities, other agencies, and external scientists, which are viewed as a valuable asset to more effective forestry research.

Recent management initiatives--especially the institution of the mid-range planning activity and the opportunities under the Chief's pilot program permitting more program allocation decisions at the local level facilitate more effective program change in the research program. Respondents at all of the Forest Experiment Stations attested to the value of the mid-range planning activity which recently has been instituted. Each sees various aspects which can be improved in this process, and presumably will be in the next iterations. However, it is viewed as a much needed link between longer term planning and the annual budget process which tends to be rushed and under substantial time pressures. Most believe that mid-range planning should provide a greater sense of continuity to Forest Service research efforts, helping to place annual adjustments in the budget process within a more orderly and rational context. The pilot program was warmly welcomed at the Northeastern Station as a means to more effectively utilize resources which came within their responsibility. Others, not so closely involved, question whether or not this "experimental" program is really new, suggesting that much of the flexibility was already within the authority of Station directors if they were willing to exercise it and take the responsibility for it. Whether or not these management flexibility opportunities have been newly instituted or only newly discovered, the important thing will be greater flexibility to deal with the need for program change via reallocation of resources at the local level.

The value in meeting user needs seems to be almost universally recognized by research leaders in the Experiment Stations. This recognition is important, because in spite of a reluctance on the part of many scientists to tolerate intervention by Forest research users, they are likely to be more tractable to such intervention because they see the value in satisfying such users. This was clearly put by a number of respondents who acknowledged that being helpful to such users resulted in support by external users in the annual appropriations process, especially during congressional hearings. As will be discussed in a later report, this recognition needs to be followed up more aggressively by Forest Service leadership to exploit those sources of support.

Networking with other researchers and research organizations, which seems to be a natural attribute of most scientists, is a definite contribution to more effective responsiveness to the need for program change. This helps broaden the horizons of Forest Service researchers, puts them in touch with the activities of others, and provides a more extensive perspective of research needs and the extent to which these various needs are being addressed.

2. Obstacles to More Effective Responsiveness

Four primary obstacles to more effective responsiveness were revealed in the course of the interviews: (1) a lack of clarity regarding Forest Service research mission; (2) inadequate communication across various levels; (3) a limited willingness to change, and (4) inadequate equipment and facilities to meet newly developing research areas (such as biotechnology) due to inadequate funds for this purpose. The lack of clarity concerning the Forest Service research mission has already been discussed, and will not be repeated here.

Inadequate communication appears to be the result of a combination of oversight and neglect. It occurs at all levels and is manifested in misunderstanding or lack of information between users and researchers, between the Washington Office and the Forest Experiment Stations (operating in both directions), and at a parallel level among Washington Office staff specialists involved in Research, State and Private Forestry, and the National Forest System. This is not universally true. We ran across a number of instances in which there were excellent regularized communications among Washington Office staff groups. However, this appeared to be the exception rather than the rule. In response to explicit questions about the number of times in the course of a year that a staff director or staff specialist would seek out the opportunity to exchange information with a counterpart in one of the other elements of the Forest Service, the response typically was not on a regular basis, and with no substantial frequency.

In spite of the commendable and frequent use of ad hoc task forces which bring together Washington Office staff and Experiment Station personnel, there does not seem to be a regularization of communication among the various staff elements and their counterparts or those with whom they should be in contact in the Experiment Stations. For example, several Experiment Station research leaders were confused about the Priority Research Program framework. They did not fully understand the difference or the connection between the priority research elements laid out in the RPA Assessment update and the Priority Research Program elements that had been announced for the current budget year. In one instance a research leader indicated that the Experiment Station was using the PRPs as a multi-year planning element, while they perceived the Washington Office as using the PRPs solely as a single budget year mechanism. This is an important operational distinction, and should be clarified. The information made available more generally to the public regarding the function of the Priority Research Program clearly indicates that this is not a single year type of effort but is one to carry Forest Research into the next decade.

Another example was the recent study done on Forest Service research needs coming out of the National Forest planning process. The data presented by the various regions and research stations varied substantially, and was impossible to track in the general report. The conclusions reached in that report are difficult to document based on the material provided by the Experiment Stations. Such substantial differences in perspective from the field to the national level need to be reconciled--and this is unlikely to occur solely through putting out the word or brief field visits. Followup is necessary to make sure that there is essential consensus of understanding.

Limited willingness to change is clearly the most pronounced obstacle to more effective responsiveness. This has a number of institutional dimensions which have become a part of the Forest Service style of operation over a number of decades and are unlikely to be changed easily. At least five different elements are involved: (1) the typical conflict between the "new" vs. traditional; (2) Forest Service "tenure" which translates into a lifetime career position; (3) the RWU "contract;" (4) the performance evaluation system used for research scientists; and (5) the relative high degree of local autonomy.

(1) The "new" vs. the traditional can be seen in the criticism by a number of Forest Service scientists who believe that the Service is making a mistake in undertaking such a heavy emphasis on biotechnology and an apparent reduction in more traditional fields such as silviculture. This concern for the more traditional research areas can be seen in a similar fashion among sister Federal research agencies. For example, the leadership of the Agricultural Research Service has been strongly criticized by some senior scientists about recent emphasis upon biotechnology there vs. such traditional research fields as agronomy. In similar fashion, senior engineers within the National Aeronautics and Space Administration Research Centers have criticized management for increasing emphasis upon computer simulation and computer aided aeronautical design in contrast to more wind tunnel testing and experimentation. This criticism is not highlighted in any attempt to make a substantive judgment about the relative correctness of a decision to emphasize one research area over another. What it does reveal is the general reluctance to change, especially where senior scientists are generally concerned about technological change, or where some have substantial career investments in particular program areas.

(2) Forest Service "tenure" is another area revealing limited willingness to change. In one set of terms it translates into the commendable practice of the Forest Service "looking after its own people." What this means is that an individual who is selected into the Forest Service and who meets initial requirements for achieving career status, is more or less assured of a career lifetime position within the Service. This is exacerbated by the natural tendency within Forest Service research to keep researchers (especially those who shun administrative responsibilities) at a particular research station for 10-15 years or more. This contributes to relative immobility both in geographical terms and in programmatic research terms.

(3) The RWU "Contract" often is viewed as just that--a contract which literally binds the research management as well as the research team. Although there obviously are shades of opinion on this, a significant proportion of research leaders and research scientists in the Forest Service believe that this contract is a pledge by management to pursue the particular areas of research without substantial change. Since the terms are typically for five years, this can reduce considerably the opportunity for responsiveness to either new opportunities or new needs where these cannot be anticipated satisfactorily in that particular time frame. It does not mean

that management cannot change this "contract" but if so, it is likely to be interpreted by researchers as a breach of faith unless they also believe that the change is in the best interests of their research.

(4) The performance evaluation system also has the effect of limiting change by reducing the potential awards (and even increasing the risks) for change. Interviews across all the Stations visited revealed specific instances where scientists were penalized at their panel review because they had to shift the focus of their scientific activity, thereby extending the time when they could demonstrate their productivity through the typical means of research publications. If the shift involved more applied research, technology transfer, or administrative/managerial orientation in terms of assistance to others, the penalties were significant--this in spite of pronouncements by the Washington Office that such activities should be given appropriate credit. The current performance evaluation system positively discourages Forest Service researchers from providing interpretive assistance or much active technology transfer to users. The Forest Service needs to address the question as to whether or not the current panel system continues to be appropriate for Forest Service needs.

(5) Local autonomy is a two edged sword with respect to user and research need responsiveness. On the one hand it can provide needed flexibility at the local level to meet local and regional demands. On the other hand, it can encourage Forest Service headquarters (or higher level organizations such as USDA) to delegate problems without appropriate support. The latter appears to be the case with respect to affirmative action and its apparent negative impact on the capacity of Experiment Stations to attract and hire the most qualified talent for research positions. Admittedly, some stations are more innovative and aggressive than others. However, the nature of the problem cuts across all occupations, and is nationwide. Therefore, it is unrealistic to put pressure on individual research leaders or particular locations as a principal means to achieve program goals. Both the Service and the Department need to assist field installations through such devices as identifying pools of eligibles, initiating outreach, maintaining central personnel data, and facilitating awareness or education programs in the target communities to help assure adequate pools to meet Forest Service needs. Mechanically mandating goals does not deal adequately with the problem.

Inadequate equipment and facilities can be overcome only through new or reallocated funds. To some extent this problem is a heritage of institutional processes and vagaries of political support. Twenty years ago Forest Service research was supported by the Congress through substantial new facilities put in place, often located in "strategic" districts of key Members. This practice continues to some degree. Some of these older facilities no longer serve primary Forest Service research needs, but have proved difficult to either reduce or remove. Even if such facilities could be closed, the Forest Service, with an annual authorization and a lack of "no year funds" finds it difficult to undertake multi-year facility or equipment purchases for their own purposes. Thus, the principal path to acquiring needed new facilities or equipment is to make a good case to both the

Administration and the Congress on the need for such facilities. FSR should consider establishing a general policy that might help prevent political intrusion on decisions of facility location--e.g. co-location with schools of forestry.

In summary, there are a number of institutional aspects which tend to limit the willingness of researchers or research leadership to change in order to be responsive to either new program opportunities, or to user needs. None will be easy to modify since each is deeply embedded in the cultural and structural system of Forest Service management; but, collectively they represent a powerful impediment to change.

IV. Case Study Results

(Somewhat expanded versions of these brief cases and conclusions therefrom are included in Appendix B).

1. Fire Research Reorganization

The leadership for fire research in Washington recognized that the general program was suffering from inadequate resources, a geographically scattered program, and what was perceived to be the loss of critical mass to sustain quality research. The objective in developing and carrying out a plan for reorganization of this research activity was to undertake a "one-shot" reorganization that would consolidate a number of research sites and provide a more rational program overall. The reorganization required the closing of several fire research activities, the transfer of scientists and support staff (e.g. technicians) to other geographic locations, and the movement of some equipment to other locations as well. Based on previous history there was concern that the traditional style of operating whereby each research unit would be fully consulted and involved in the planning of substantial research changes could not be followed if successful completion of the reorganization were to be assured.

It was believed that the affected activities would generate political support that would thwart the reduction of fire research at particular locations or the transfer of individuals and equipment. This proved to be true in several instances, although the basic program change was accomplished and the consolidations made. In this process the station directors and assistant directors for research were consulted by the Washington Office. Reorganization plans were developed in Washington and passed to the field for implementation. The specific research scientists and technicians involved were not notified until the announcement from Washington of the full reorganization was made.

There were some important costs in the accomplishment of this reorganization: (1) there was the anticipated disruption in research at the affected field stations from the time of the announcement through the first year or more after the consolidations occurred; (2) a number of valuable scientists were lost to the Forest Service who refused to make the physical move, and took employment elsewhere; and (3) the reorganization appeared to

violate what had been a Forest Service practice of "looking after their own," through prior consultation and involvement in arrangements. This is not to say that the planning did not include adequate protection of individual's job tenure. However, it did not anticipate the strong resistance to physically moving from one location to another by the scientists or technical support staff. Although there was the loss of several scientists, including some with expertise that proved difficult to replace, the other side of that coin was that there were research slots opened which provided the opportunity to bring in new and younger people to participate in fire research.

This brief case demonstrates two important considerations regarding responsiveness to the need for program change. The first is the need for research management to make difficult and sometimes unattractive decisions if one is to retain a quality scientific program. Second, it reveals the strong tendency on the part of the research organization to resist change strongly--indeed it was recognition of this stance that encouraged the Washington Office staff director to bypass the more traditional consultative approach to change in order to avoid undercutting what he saw as a necessary change. In the process, there were several unanticipated negative outcomes, including some loss of trust in the traditional paternalism of the Forest Service.

2. Acid Rain Program

The Acid Precipitation Act of 1980 established a task force to oversee and coordinate the National Acid Precipitation Assessment Program (NAPAP). The Forest Service became the lead agency for the Department of Agriculture in this effort, and received new program funds directly as well as funds transferred from the Environmental Protection Agency (EPA). This is an instance where a major national policy thrust on the part of Congress and the Administration provided an opportunity and new resources to undertake research related to forestry concerns. It represents a combination of the extension of then current research, some refocussing of research, and substantial expansion through new programs. In order to meet a rather substantial infusion of new financing, the Forest Service established at the national level a program management focus with a program management matrix structure whereby various projects could be undertaken at a number of Forest Experiment Stations with grants and contracts related to those specific assignments managed by the respective Experiment Stations.

In one respect, responsiveness to this type of program change was facilitated by two important elements: first, it was a national program initiative cutting across government agency lines and strongly supported by both the Congress and the Administration. Second, it brought with it an infusion of new money which provided opportunities for forestry-related research that had not previously been available. However, this did not reduce a number of substantial program implementation challenges. (It's important to recognize that these are implementation challenges, and not research decision challenges). One of these challenges was accommodating a non "forestry" agency such as EPA. EPA being a regulatory agency, not a traditional scientific organization, provided the Forest Service a new series

of challenges in communication, understanding, and coordination. Another challenge was the imposition of a detailed preplanning process that promoted standardization of research methodology, rather than the experimentation familiar to Forest Service scientists, in order to meet stringent schedule goals. This early standardization of method, while necessary to meet a program schedule, was viewed by some as preempting experimentation that could determine the optimum research method, and lead to superior scientific results.

A third challenge was the relatively stringent quality control requirements placed upon the research program by EPA. This was to meet the world of the regulatory agency--especially the requirement that this data be able to be well defended in the judicial arena where nearly any substantial environmental question migrated sooner or later. In this instance, a special quality control function was established by the EPA to monitor research and to assure that research data and results had a systems reliability to them that could meet EPA's needs. This type of "quality control" was considerably different from that to which Forest Service researchers had been accustomed--i.e. the technical peer review and professional journal refereeing which usually suffices for the scientific community. This particular quality control element was not completely palatable to Forest Service researchers participating in the program. It became apparent to the research management of the Service that the opportunity to participate in this highly attractive research hinged upon meeting EPA's needs, and that stance apparently facilitated acceptance.

In retrospect some have acknowledged that this type of quality control provided a useful experience to Forest Service researchers that would be valuable in the future, despite being a considerably different approach than what they were used to. In this case change was sweetened by new sources of research support and the opportunities to undertake new research initiatives.

Watershed Research

Forest Service watershed research recently has been recast to focus upon cumulative affects rather than the past emphasis on water quantity. Some respondents in the field were unable to discern a "reorganization" probably because it was not done quickly but tends to be a classic instance of incremental change. In this case there was a gradual shifting focus within the field of watershed research by the RWUs, with the change being generated both through initiative from the field as well as a new aggregate focus at the Washington Office level. In essence, a broad overview has been provided for a reconstituted effort directed toward water quality, siltation, nutrient and chemical composition, and a variety of other aspects important to watershed management. Change was not abrupt, but incremental, and researchers tended to be led toward opportunities for research funding that neither dislocated people nor required rapid refocussing of research efforts. An important element appears to have been that needed change was anticipated among researchers, coupled with a substantial willingness to make that change.

In summary, these mini cases reveal a significant variation in organizational responsiveness to the need for change and key factors which made such change either easier to accomplish or more difficult. Obviously key elements were the speed with which changes were made, and the availability of new resources to facilitate the change and to attract willingness to change. Time and resources can be powerful tools in overcoming resistance to change.

V. Preliminary Conclusions and Observations

In summary, the effectiveness of program change mechanisms in Forest Service research was judged by six criteria: (1) degree of program flexibility, (2) key opportunities actually undertaken, (3) ease of program change, (4) relative willingness to change, (5) expectations of senior leadership and users, and (6) integration with other research. On the whole, Forest Service Research demonstrated that there is substantial capability and considerable flexibility supporting effectiveness of change. The principal weakness noted in the application of the six criteria related to relative willingness to change, with some deficiencies on the criterion of integration with other research--principally related to a less than satisfactory outreach to the broader scientific community. Again, the capability and considerable flexibility exist to achieve effectiveness in program change; what appears to be lacking is the will to use it.

Such a harsh judgement must be tempered by: (1) several institutional factors that operate largely from either the Forest Service ethos or past practices, and (2) some current constraints over which the Forest Service has limited influence. Central to all of this is the absence of any clear consensus--Forest Service-wide--as to what the Forest Service Research mission is.

Basic change in the structure for research planning and decision is not required and would not materially improve responsiveness nor lessen the challenge of hard decisions. The recent work on mid-range planning should be continued and perfected, with a carefully limited number of Priority Research Programs serving as focal points.

Forest Service Practices That Limit The Effectiveness For Program Change

Four practices stand out as having inhibited the capability to effect program change. Each is within the control of the Forest Service to modify, as it sees fit. These are: (1) "the Forest Service looks after its own," (2) the conservative nature of the panel system, (3) local autonomy in conjunction with the relatively fuzzy role of the Washington Office, and (4) the practice of exploiting local political ties to bypass or overcome central agency decisions.

As noted earlier, the ethos of "looking after its own" by the Forest Service is a commendable one. It tends to translate into the practice of

avoiding hard program decisions that will have the effect of hurting individuals. In actual practice this has not been fully honored as we were given examples during the field interviews where scientists were put at risk, e.g., through pressure to do work outside the RWU description, without much apparent management forethought. Concern with the individual is very important because the Forest Service's principal resource is its people and their skills. But like any large public organization, there will be times when the larger requirements of the organization require decisions which will have a detrimental impact on individual participants. These consequences need to be ameliorated to the extent that they can be, but the leadership cannot avoid hard program decisions.

The Forest Service panel system used to assess performance of its research scientists was borrowed essentially from the Agricultural Research Service. As currently practiced it does not support an effective reward system that appears to be required to meet Forest Service Research needs. Admittedly, the extent to which the current panel system will fit those needs depends largely upon how one views the Forest Service Research mission--which remains unclear.

The practice of strong local autonomy throughout the Forest Service has its roots both in history and in a fundamental management principle that one should leave decision making and action at that point closest to the problem. This practice combined with a relatively fuzzy role of the Washington Office tends to obscure where responsibility lies with respect to some program decisions, and it leads to inconsistency and a limited capability to rationalize the Forest Service Research Program in terms of national need.

There has been a history of Forest Experiment Stations exploiting local political ties to mitigate or bypass central office (or higher) decisions which are considered unacceptable. The same practice has been used in the competition for resources, and allegedly has occurred with the concurrence (or in the face of opposition) of the Washington Office. This process, though diminished in recent years, tends to have long term consequences in terms of scattered facilities and inadequate resource support (as the political sponsor fades), in conjunction with the undercutting of the central organization's authority.

External Constraints Which Tend To Inhibit Program Change Effectiveness

The two constraints to program change effectiveness which were noted most frequently in discussions with Forest Service officials, and over which the Forest Service itself has little or limited influence are: (1) the low priority for natural resources research in the Federal government as a whole, and (2) the relatively mechanical approach that tends to be taken with respect to affirmative action goals under the equal employment opportunity program.

The Task V report on perceptions of Forest Service Research competitiveness will explore in greater detail the nature and consequences of the relatively

low priority for natural resources research as this affects the Forest Service. However, it is fair to say that this low priority--generally in the Congress, the top levels of the Administration, and at the Departmental levels--results in serious resource constraints within which Forest Service Research must operate. An important element of this constraint is the question of whether or not Forest Service Research is rated of sufficient importance within the Forest Service to provide successful support in seeking additional resources at the higher political levels. This issue will be addressed more directly and fully in reports on Tasks V & VI.

The general goals of the Federal Government's affirmative action program are commendable, but they reveal a lack of both realism and management imagination as they are specifically applied. Without more conscious and organized support from the top levels of government, through the Department, through the Forest Service, to the Forest Experiment Stations, mechanistic attempts to meet these goals could result in very substantial damage to scientific credibility and value of Forest Service research, and to the morale of younger scientists. The Forest Service is not a large agency, and it has limited control with respect to this issue. However, the full nature of potential impact, realistic means to deal with the "requirements" which have been passed down, and clear feedback to higher authority are within Forest Service management's command. Senior leadership in the Service, both in the Washington Office and Forest Experiment Stations, needs to come together to explore practical means to address this problem.

Issues Raised But Not Fully Addressed

In the course of this study several paramount issues have arisen which bear directly upon the mandate of the study team, but which are broader in nature than is the study's primary focus. These will be treated more extensively in the final (Task VI) report. These issues are: (1) Forest Service Research mission, (2) Forest Service leadership for research, and (3) Forest Service organization for research. Each of these is very important, and well-recognized throughout the Service; but they tend to be pushed aside or finessed, without resolution, in dealing with day to day affairs or with the principal topics of this study.

Forest Service Research Mission

There seems to be a general assumption among senior management in the Forest Service that a consensus regarding the Forest Service Research mission exists, but this certainly has not been evidenced in the interviews at the Washington Office or in the field. What is needed is a succinct statement of what constitutes the research mission (being careful not to promise all things to all people) so that appropriate clarity can be furnished which, in turn, will provide the benchmarks for research leadership and for the Forest Service organization. It seems reasonably clear that some of the confusion regarding research organization, how to meet various management challenges, how to most appropriately seek needed resources, etc.--all relate to how one views the Forest Service Research mission, and the variations in that perspective inhibit achieving consensus on the other issues which follow from it. For example, if the primary mission of Forest Service Research is

considered to be the vehicle for natural resources research across the United States (perhaps even worldwide), then the current organization and arrangements for support may be woefully inappropriate. The point is not whether the current Forest Service Research fits that descriptive role; rather, it is whether that should be the principal research goal of the organization. On the other hand, if one takes the perspective that Forest Service research is primarily to serve the needs of the National Forest System, one will approach questions of organization, resource justification, even recruitment, in a somewhat different fashion.

Forest Service Leadership For Research

A number of questions have arisen in the course of this study which unavoidably relate to the broad issue of Forest Service leadership for research. This general term "Forest Service leadership" should be taken to include the Deputy Chief and immediate associates, Washington Office staff directors, Forest Experiment Station directors and their top assistants. An example of the type of questions which have frequently arisen are as follows. Is the leadership making the right kind of effort, and with sufficient energy, to "make the case" for Forest Service Research--within the Forest Service as well as to the Department of Agriculture, the Administration, and the Congress? To what extent is the leadership providing strong science leadership, not only to the forestry research community, but to the biological research and science community at large, or particularly the Washington science "establishment?" Is there adequate communication among the leadership elements of Forest Service Research, with systematic management follow-through? How vigorous and effective is management in supporting the function of technology transfer and enforcing the management requirements related thereto? In each of these areas the study team has run across a number of examples of apparent deficiencies or concerns by knowledgeable participants or observers.

Forest Service Organization For Research

Although not a central focus of this study, Forest Service organization for research requires serious attention because the two principal concerns addressed--effectiveness for program change and competitiveness of Forest Service research relate closely to a series of issues which might be addressed through modifications in the research organization or its broader management procedures. Again, this general issue will not be discussed in detail here, but will be in the Task VI report containing options for action. For example, some of the concerns that have cropped up which are related to this general topic include the following. What is, and should be, the relationship between Forest Service Research, the National Forest System, and State and Private Forestry? What are the respective roles and relationships between (and among) the Forest Experiment Stations and the Washington Office, and what changes might prove useful? The Forest Service typically has conducted the vast bulk of its research in-house. Is this a useful practice to continue, or should greater attention be given to using the contract/grant mechanisms to achieve Forest Service research objectives? What is and should be the role of universities--particularly schools of forestry--with respect to Forest Service Research? Apart from needed clarification, is the current

degree of decentralization/centralization of Forest Service research the most useful way to approach its mission?

Each of the above issues or questions needs consideration, as each affects our study objectives of dealing with program change effectiveness and research competitiveness. However, information collected during the course of this study suggests that, in some cases, these questions or issues are at the heart of research effectiveness, whereas program change mechanisms or the concern for effectiveness may be symptoms of either a deeper of more general problem. The study team has collected considerable information that bears on these issues/questions and will endeavor to constructively address them in the Task VI report. It needs to be emphasized again that these are questions which clearly have bothered most Forest Service officials at one time or another, but which have not been systematically addressed in the fashion which permits their resolution.

STUDY PROJECT:
ASSESSMENT OF THE COMPETITIVENESS OF FOREST SERVICE RESEARCH

Task IV Report

Assessing the Competitive Standing of Forest Service Research

January 15, 1988

Task IV: Assessing the Competitive Standing of Forest Service Research

Introduction

Assessment of the competitive standing of Forest Service Research (FSR) is a challenging task at best. There is no consensus as to what form of competition exists, who the competitors are, or how competitiveness can be measured. As a result, some activities are measured objectively because they are suitable for objective or quantitative measurement, not necessarily because they are the most important measures of competitiveness. Other activities or characteristics of Forest Service Research that appear important--e.g., research quality or satisfaction of users of the research--can be assessed only in subjective ways.

Therefore, in lieu of a universally accepted method for scoring or ranking competitiveness such as exists in athletics, a series of characteristics has been chosen for some type of measurement. These are:

Congressional willingness to fund Forest Service Research
Ability of Forest Service Research to attract outside funding
Success in competition for grants
Professional journal authorships
Professional journal citations
Leadership in professional societies

It is hoped that an overview of these various measures will provide a useful indication of the competitiveness of Forest Service Research.

Congressional Willingness to Fund Forest Service Research

Competitiveness of a firm in the private sector is fairly judged by trends in sales and profit. The firm competes in the market place against other firms that produce similar goods or services, and succeeds or fails based on the quantity of its outputs and the skill of its management. If its market sector shrinks, the firm is free to diversify into new and growing sectors and thus improve sales and profitability.

Within the Federal Government, however, the use of trends in approriations is an imperfect measure of an agency's competitiveness, except in the broad sense that every Federal program competes with every other program for funding. Willingness of the Congress to fund an agency's program does not depend only on congressional perception of the quality of the agency's accomplishments and of its management. Appropriations also reflect congressional perception of the national importance of the agency's program and mission relative to other agencies' missions. In a time of budget cutting, the Congress may reduce funding for many worthwhile and well-managed programs while increasing funds for programs it considers of greater priority, e.g., defense. Lacking authority to diversify missions or programs, agency administrators can do relatively little to affect this. Nevertheless, trends

in appropriations are of paramount importance to an agency's future and thus deserve careful analysis to determine how competitiveness might be enhanced.

Between FY 1979 and FY 1987, appropriations for Forest Service Research grew from $95.0 million to $125.8 million, a 32.4 percent increase in current dollars. (See Table 1.) However, Forest Service Research appropriations grew more slowly than for the entire group of USDA research programs (which grew by 55.1 percent) and shrank by 14.8 percent in constant dollars during the FY 1979-1987 period. (See Table 2.)

When compared with nearly all other USDA research programs, Forest Service Research appropriations lagged behind. While FSR grew by 32.4 percent in current dollars, Agricultural Research Service (ARS) grew by 57.7 percent, Cooperative State Research Service (CSRS) by 65.7 percent, and Economic Research Service (ERS) by 61.1 percent.[1] While the combination of all other USDA research programs gained 2.0 percent in constant 1979 dollars (i.e., purchasing power) between FY 1979 and FY 1987, Forest Service Research funding shrank by 14.8 percent in constant dollars over the same period.

This shrinkage continues in the FY 1988 Budget. Forest Service Research appropriations are expected to drop from $125.8 million to $122.2 million.[2,3] While this reduction reflects a transfer of the Competitive Grants program to CSRS, the regular research appropriation of $122.2 million for FY 1988 is actually worth $4.9 million (4.0 percent) less than in FY 1987, measured in constant 1987 dollars.[2]

Most other USDA R & D programs are expected to receive greater funding in FY 1988 than in FY 1986 or 1987. (See Table 3.) Except for elimination of a $5.2 million special grants program in CSRS, most R & D programs grew in funding in FY 1988 over FY 1987: ARS by 5 percent; and ERS by 8 percent.

In contrast, R & D programs of the natural resources and environment agencies (including the Forest Service) are reduced by 5 percent from FY 1987 to FY 1988. (See Table 4.) This occurs despite a 4 percent funding increase in the pollution control and abatement programs of Environmental Protection Agency (EPA) and a 2 percent increase in funding for the Geological Survey's R & D programs. Major funding reductions for natural resources agencies include a 59 percent cut in the Bureau of Reclamation due to elimination of the atmospheric water program in FY 1988; a 23 percent cut in National Oceanic and Atmospheric Administration's (NOAA) appropriations reflecting the termination of several R & D programs, including fisheries programs and weather modification grants; and a 4 percent reduction in R & D programs of the Bureau of Mines.

In summary, judged by R & D appropriations trends, Forest Service Research is not competitive with most other Federal programs. That is, Forest Service Research funding has shrunk by 14.8 percent in constant (1979) dollars from FY 1979 to FY 1987 and will shrink another 4.0 percent in constant (1987) dollars from FY 1987 to FY 1988.

In contrast, the entire R & D budget of the Federal Government has grown from $ 28,208 million in FY 1979 to $58,148 million in FY 1987, an increase of 206 percent in current dollars and 33 percent in constant (1979) dollars. The Federal R & D budget is estimated to increase by 16 percent, to $67,576 million, in FY 1988.[4]

Table 1.
U.S. Department of Agriculture: Appropriations for research and education, FY 1979-87

Item	1979	1980	1981	1982	1983	1984	1985	1986[1/]	1987
Research	Million dollars								
Agricultural Research Service[2/]	328.0	358.0	404.1	423.2	451.9	469.0	492.1	483.2	517.2
Cooperative State Research Service[3/]									
Hatch Act Formula	109.1	118.6	128.6	141.1	147.2	152.3	156.5	148.8	148.8
Cooperative Forestry	9.5	10.0	10.8	12.0	12.4	12.7	13.1	12.4	12.4
1890 Colleges and Tuskegee	16.4	17.8	19.3	21.5	21.8	22.8	23.5	22.3	22.3
Special Research Grants	16.3	15.2	18.2	23.1	27.8	26.5	33.2	29.0	52.0
Competitive Research Grants	15.0	15.5	16.0	16.3	17.0	17.0	46.0	42.3	40.7
Rural Development Research	1.5	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Animal Health and Disease	5.0	6.0	6.5	5.8	5.8	5.8	5.8	5.5	5.5
Direct Federal Administration	1.5	1.3	1.3	0.8	0.3	0.6	1.5	1.5	2.6
Forestry Competitive Grants	0.0	0.0	0.0	0.0	0.0	0.0	7.8	6.5	4.5
Total, CSRS[3/]	174.3	185.9	200.7	220.6	232.3	237.7	287.4	268.3	288.8
National Agricultural Statistics Serv.	5.4	5.0	7.5	7.0	7.6	8.2	8.4	8.0	8.2
Economic Research Service	28.2	26.1	39.5	39.4	38.8	44.3	47.1	44.1	45.4
Human Nutrition Information Service	6.6	7.1	8.2	8.5	7.7	6.1	7.5	12.9	6.9
Animal and Plant Health Inspection Serv.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	4.7
Agricultural Cooperative Service	2.0	1.6	1.8	1.7	2.2	2.2	2.9	2.7	2.7
Agricultural Marketing Service	1.0	1.3	1.4	1.5	1.5	1.6	1.6	1.5	1.5
Office of Transportation	0.7	0.8	0.9	1.0	0.8	0.8	1.3	1.1	1.1
Office of International Coop. and Devel.	6.6	5.3	5.0	0.7	5.5	5.3	5.4	3.1	2.5
Forest Service	95.0	95.9	108.4	112.1	107.7	108.7	113.8	113.6	125.8
Federal Grain Inspection Service	0.4	0.5	0.5	0.6	0.6	0.7	1.1	0.9	1.1
Total, research	648.2	687.5	778.0	816.3	856.6	884.6	968.6	943.8	1,005.9
Education									
Extension Service									
Smith-Lever 3(b&c) Formula	179.8	189.3	205.4	219.4	230.4	235.0	241.5	229.7	229.7
Other Extension Programs	77.5	78.2	80.7	90.0	92.8	93.8	96.8	93.1	96.5
Direct Federal Administration	6.5	6.5	6.1	6.3	5.4	5.5	5.4	5.2	6.0
Total, Extension Service	263.8	274.0	292.2	315.7	328.6	334.3	343.7	328.0	332.2
Cooperative State Research Service									
Bankhead-Jones	11.5	11.5	11.5	0.0	0.0	0.0	0.0	0.0	0.0
Morrill-Nelson	2.7	2.7	2.7	2.8	2.8	2.8	2.8	2.8	2.8
Competitive Fellowship Grants	0.0	0.0	0.0	0.0	0.0	5.0	5.0	2.9	2.9
1890 Colleges Grants	0.0	0.0	0.0	0.0	0.0	0.0	2.0	1.9	1.9
Total, CSRS	14.2	14.2	14.2	2.8	2.8	7.8	9.8	7.6	7.6
National Agricultural Library	7.0	7.3	8.2	8.2	9.1	10.4	11.5	10.8	11.1
Total, education	285.0	295.5	314.6	326.7	340.5	352.5	365.0	346.4	350.9
Total, research and education	933.2	983.0	1,092.6	1,143.0	1,197.1	1,237.1	1,333.6	1,290.2	1,356.8

1/ Reflects reductions under P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985.

2/ Excludes ARS construction funding, which has been (in million of dollars): $36.7 ('79), $0 ('80), $12.1 ('81), $8.6 ('82), $4.9 ('83), $77.9 ('84), $22.4 ('85), $6.1 ('86), $37.4 ('87).

3/ Excludes 1890 Colleges and Tuskegee Research Facilities funding, which has been $10.0 million annually from FY 1983 through FY '85 and $9.5 million each in FY '86 and FY '87.

Source: Office of Budget and Program Analysis (OBPA), USDA.

Table extracted from Ref. 1

Table 2.
U.S. Department of Agriculture: Appropriations for research and education in constant 1979 dollars, FY 1979-87

Item	1979	1980	1981	1982	1983	1984	1985	1986	1987
Research									
Inflation rate		11.3%	9.2%	7.1%	4.0%	4.4%	4.1%	2.3%	3.
GNP deflator for gov't. purchases Index: (1982=100)	76.8	85.5	93.4	100.0	104.0	108.6	113.1	115.7	119.
					Million dollars				
Agricultural Research Service	328.0	321.6	332.3	325.0	333.7	331.7	334.2	320.7	332
Cooperative State Research Service									
Hatch Act Formula	109.1	106.5	105.7	108.4	108.7	107.7	106.3	98.8	95
Cooperative Forestry	9.5	9.0	8.9	9.2	9.2	9.0	8.9	8.2	8.
1890 Colleges and Tuskegee	16.4	16.0	15.9	16.5	16.1	16.1	16.0	14.8	14.
Special Research Grants	16.3	13.7	15.0	17.7	20.5	18.7	22.5	19.2	33
Competitive Research Grants	15.0	13.9	13.2	12.5	12.6	12.0	31.2	28.1	26
Rural Development Research	1.5	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Animal Health and Disease	5.0	5.4	5.3	4.5	4.3	4.1	3.9	3.7	3.
Direct Federal Administration	1.5	1.2	1.1	0.6	0.2	0.4	1.0	1.0	1
Forestry Competitive Grants	0.0	0.0	0.0	0.0	0.0	0.0	5.3	4.3	2
Total, CSRS	174.3	167.0	165.0	169.4	171.5	168.1	195.2	178.1	185.
National Agricultural Statistics Serv.	5.4	4.5	6.2	5.4	5.6	5.8	5.7	5.3	5.
Economic Research Service	28.2	23.4	32.5	30.3	28.7	31.3	32.0	29.3	29.
Human Nutrition Information Service	6.6	6.4	6.7	6.5	5.7	4.3	5.1	8.6	4.
Animal and Plant Health Inspection Serv.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	3.0
Agricultural Cooperative Service	2.0	1.4	1.5	1.3	1.6	1.6	2.0	1.8	1.
Agricultural Marketing Service	1.0	1.2	1.2	1.2	1.1	1.1	1.1	1.0	1.
Office of Transportation	0.7	0.7	0.7	0.8	0.6	0.6	0.9	0.7	0.
Office of International Coop. and Devel.	6.6	4.8	4.1	0.5	4.1	3.7	3.7	2.1	1.
Forest Service	95.0	86.1	89.1	86.1	79.5	76.9	77.3	75.4	80.9
Federal Grain Inspection Service	0.4	0.4	0.4	0.5	0.4	0.5	0.7	0.6	0.
Total, research	646.2	617.5	639.7	626.9	632.6	625.6	657.7	626.5	647.
Education									
Extension Service									
Smith-Lever 3(b&c) Formula	179.8	170.0	168.9	168.5	170.1	166.2	164.0	152.5	147.
Other Extension Programs	77.5	70.2	66.4	69.1	68.5	66.3	65.7	61.8	62.
Direct Federal Administration	6.5	5.8	5.0	4.8	4.0	3.9	3.7	3.5	3.
Total, Extension Service	263.8	246.1	240.3	242.5	242.7	236.4	233.4	217.7	213.
Cooperative State Research Service									
Bankhead-Jones	11.5	10.3	9.5	0.0	0.0	0.0	0.0	0.0	0.
Morrill-Nelson	2.7	2.4	2.2	2.2	2.1	2.0	1.9	1.9	1.
Competitive Fellowship Grants	0.0	0.0	0.0	0.0	0.0	3.5	3.4	1.9	1.9
1890 Colleges Grants	0.0	0.0	0.0	0.0	0.0	0.0	1.4	1.3	1.
Total, CSRS	14.2	12.8	11.7	2.2	2.1	5.5	6.7	5.0	4.
National Agricultural Library	7.0	6.6	6.7	6.3	6.7	7.4	7.8	7.2	7.1
Total, education	285.0	265.5	258.7	250.9	251.4	249.3	247.9	229.9	225.
Total, research and education	933.2	862.9	898.4	877.8	884.0	874.9	905.6	856.4	872.

Source: OBPA, USDA.

Table extracted from Ref. 1

Table 3

R&D budget authority for agriculture

[Dollars in millions]

	1986 actual	1987 estimate	1988 estimate
Total	$815	$865	$839
Agricultural Research Service (USDA)	468	502	527
Research on plant productivity	183	193	207
Research on commodity conversion & delivery	88	101	105
Research on animal productivity	87	90	95
Research on soil & water conservation	59	60	61
Human nutrition research	37	40	41
Integration of agricultural systems	8	12	12
Miscellaneous contributed funds	5	5	5
Contingency research funds	1	1	1
Cooperative State Research Service (USDA)	268	289	238
Payments under the Hatch Act	149	149	156
Competitive research grants	42	41	45
Biotechnology	19	19	19
Plant science	14	12	16
Animal science	4	4	7
Human nutrition	2	2	3
Pest science	3	3	-
Payments to 1890 colleges and Tuskegee Institute	22	22	23
Cooperative forestry research	12	12	13
Special grants	29	52	-
Animal health and disease research	6	6	-
Forestry Competitive Grants	7	5	-
Administration	2	3	2
Economic Research Service (USDA)	44	45	49
National Agricultural Statistics Research (USDA)	8	8	9
Human Nutrition Information Service (USDA)	13	7	9
Animal and Plant Health Inspection Service (USDA)	4	5	3
Agricultural Marketing Service (USDA)	2	2	2
Office of Transportation (USDA)	1	1	1
Federal Grain Inspection Service(USDA)	1	1	1
Agricultural Cooperative Service (USDA)	3	3	-
Office of International Cooperation and Development (USDA)	3	3	-

Table extracted from Ref. 3

Table 4

R&D budget authority for natural resources and environment
[Dollars in millions]

	1986 actual	1987 estimate	1988 estimate
Total	$1,062	$1,083	$1,029
Pollution control and abatement (EPA)	268	282	292
Conservation and land management	120	133	129
Forest Service (USDA)	114	126	122
Bureau of Land Management (Int)	3	3	3
Office of Surface Mining and Reclamation (Int)	2	3	3
Minerals Management Services (Int)	1	1	1
Recreational resources	62	70	71
Fish and Wildlife Service (Int)	46	54	52
National Park Service (Int)	16	16	19
Water resources	44	40	39
Corps of Engineers (DOD)	34	30	35
Bureau of Reclamation (Int)	11	10	4
Other natural resources	568	559	498
National Oceanic and Atmospheric Administration (Commerce)	270	277	215
Geological Survey (Int)	219	208	212
Bureau of Mines (Int)	79	74	71
Office of the Secretary (Int)	1	-	-

Table extracted from Ref. 3

Major increases in R & D programs for FY 1988 over FY 1987 are expected in national defense (up 16.9 percent, with SDI research increasing by 40 percent); health (up 30.9 percent, with AIDS research increasing by 36 percent); space research and technology (up 17.9 percent, with space transportation systems increasing by 43 percent); and general science (up 14.3 percent). These are the four R & D areas receiving the largest shares of the Federal R & D budget, a combined share of 92 percent.[5] The growth of Federal R & D funding by major function, from FY 1978 to FY 1988 is shown in Figure 1.

While not competitive with major Federal R & D programs, nor with funding for other R & D programs of the USDA from FY 1979 to FY 1987, Forest Service Research did no worse than other USDA R & D programs in the current budget. In FY 1988, Forest Service Research funding fell by 3 percent in current dollars from the FY 1987 level, by elimination of the competitive grant program. The remaining USDA R & D budget shrank by 3 percent also, largely because of elimination of the special grants program and three other programs in CSRS and the elimination of funding for Agricultural Cooperative Service (ACS) and Office of International Cooperation and Development (OICD). However, two of the USDA research agencies, ARS and ERS, both received increases in funding of 5 and 8 percent, respectively, which indicates a competitive advantage for both over Forest Service Research.

When compared with other natural resources and environment research programs, Forest Service Research does show a modest competitive edge. This group of R & D programs gained 2 percent in funding from FY 1986 to FY 1987, while Forest Service Research gained 7 percent. From FY 1987 to FY 1988, Forest Service Research funding shrank less (-3 percent) than the funding of the group of natural resources programs (-5 percent).

An overall assessment of Forest Service Research competitiveness in terms of receiving congressional appropriations is not favorable. This primarily reflects congressional attention to four major programs which have the highest priority and which receive 92 percent of federal R & D funds. Although Forest Service Research fares reasonably well when compared with natural resources and environmental programs, these programs are among the least favored by congressional appropriators and receive funding that tends to shrink in current dollars, and shrinks even more in purchasing power.

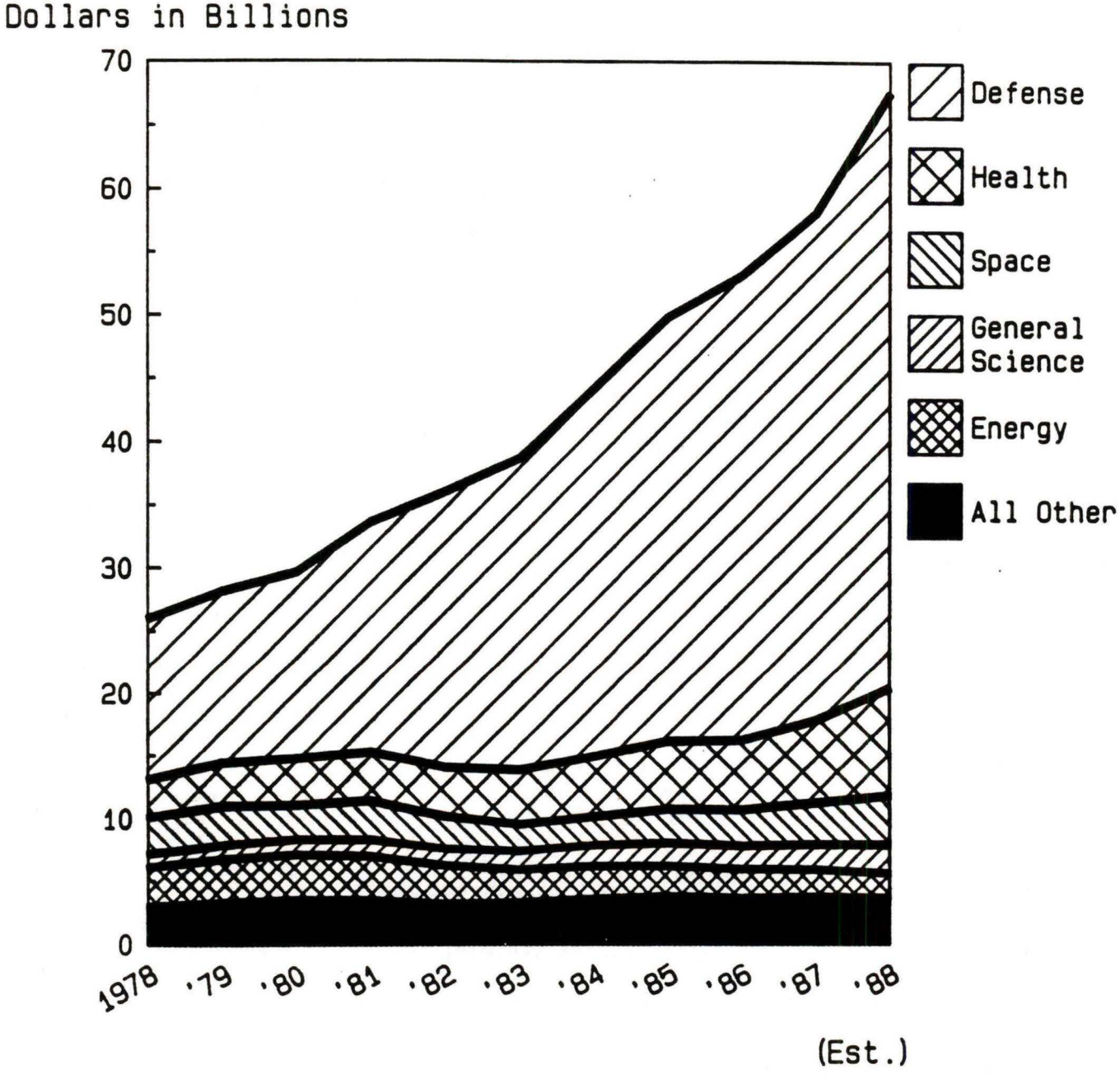
Thus far, the issue of Forest Service Research competitiveness in obtaining congressional appropriations has been described empirically, i.e., by describing the relative shrinkage of the FSR budget in constant dollars when compared with other Federal R & D programs. This is a rather simplistic description that implicitly assumes that the Congress appropriates funds among programs on a level playing field, with perfect knowledge of the results to be achieved from that funding. Such a view ignores the roles of the Forest Service and USDA administrators, Office of Management and Budget (OMB) and the political process of constituency support in the appropriations process.

In fact, interviews with knowledgeable persons outside the Forest Service have attributed the reduction in Forest Service Research funding to a former Assistant Secretary for Natural Resources and the Environment, John Crowell.

Figure 1

Federal R&D Funding by Major Function

Cumulative



SOURCE: National Science Foundation, SRS

Figure extracted from Ref. 3

They described him as unsympathetic to research, influential in reducing research budgets and "promoting the sale of more old growth timber in the West." This view was confirmed in a 1984 address by a top USDA budget official:

> The Assistant Secretary for Natural Resources and the Environment has been making tradeoffs among forestry programs at USDA for several years. They unambiguously indicate a perception of low productivity for research at the margin compared with other alternatives for increasing forest productivity, timber supplies, and other resource supplies. There is no other way to interpret it.[6]

The departmental budget evaluation process stresses the need for evaluating research in terms of its future effectiveness, particularly in improving productivity. It appears easier to do so in the case of agricultural research than forest research, and this is reflected in the relative sharing of research funds in the USDA. As the USDA budget official stated:

> Agricultural productivity improvement was observed to slow in the late 1960's. It was also observed to slow in the 1970's, after a sharp increase in 1971. These patterns may or may not have been aresponse to the slowdown in research funding. Nevertheless, . . . [s]everal studies on the effectiveness of agricultural research and on new priorities for an expected long-term rising trend in world food demands and U.S. exports were commissioned, primarily by Congress. A great deal of congressional attention was focused on means to improve both agricultural productivity and related research productivity. This resulted in identifying new research priorities, emphasis on basic research, and an increase in Federal funding which has continued through this Administration.[7]

In contrast, the budget official cited an example in which the Forest Service economists and scientists predicted a major reduction in future timber demand as a result of emerging technology, yet failed to request funding to conduct utilization research--funding that presumably would have been forthcoming.[8] This example may reflect a basic difference in research philosophy between the Forest Service and the USDA, the former promoting a balance of research efforts in many scientific fields, some of them long-term in nature, and the latter promoting research that has a rapid payoff from the investment of R & D funds. The Forest Service Deputy Chief for Research, Robert Buckman, responded to the USDA budget official:

> I don't dispute the notion that the biggest gains in forestry have come from utilization research, but I also have the feeling that there is a very strong neglect of what the biological contributions have been. The utilization gains tend to be easily identifiable, easily described . . . something tangible and concrete that you can hold in your hand . . . structural flakeboard, pressdried

> paper, things of that sort. Whereas a lot of the gains in biology have been incremental and lots of people have made small contributions, but in the aggregate the contributions are enormous.[9]

One of the forestry organization officials who was interviewed emphasized the influence of political leadership on the research appropriations process, contrasting the Crowell period with the improvement following his replacement by Pete Meyers. "It took a lot of work from Buckman and others to keep research alive. Our organization worked like hell to help out." The official also contrasted the active role of Secretary James Watt in obtaining increased appropriations for national park development with that of the Forest Service. "As a result [of Watt's aggressive testimony] we have national parks that have eight times the maintenance of adjacent national forests that have twice the visitor days. The Forest Service is still depreciating the investment made by the CCC. Political leadership matters!"

The forestry organization official further stated that there is a good reaction to Forest Service Research on Capitol Hill, and as a result the Forest Service Research budget has been kept at or above levels requested by the Administration. He remarked, "There is more sympathy for Forest Service Research in Congress than in OMB."

His opinion is supported by congressional comments made during the 1988 budget hearings. Representative Les AuCoin quizzed Chief Robertson and Assistant Secretary Dunlop at length over reductions made in the USDA budget submission for long term research on forest and forest environments. Representative AuCoin summarized his concerns:

> Let me tell you what my objection is to the structure of this budget submission. When it comes to immediate outputs, economic outputs from the forests, the budget submission does pretty well in terms of the money that it requests. But when you get to investments in the forests, research, which is what the Chairman has raised, reforestation and timber stand improvement, wilderness management, land acquisition, fish habitat enhancement, soil and water, air management, State and private forestry, all the things that deal with the long range health of the forests, every one of those categories are slashed. So, in terms of the long-term investment items, OMB has seen fit and the Administration has seen fit to short-change this budget. When it comes to the immediate output items in the budget, it has seen fit to put a level of dollars in there that are relatively high. . . . I think a question of balance is extremely important, unless you believe--maybe you do--in a "here today, gone tomorrow" approach to the National Forests.[10]

Subsequently, Representative AuCoin and Representative Ralph Regula asked Assistant Secretary Dunlop to explain why the Forest Service Research budget submission had been reduced, why funding was cut back for research on spruce budworm infestation and on acid rain research, when the ARS budget has been increased by $26 million. Representative Regula commented, "when we have

enormous surpluses, it seems rather inconsistent to be increasing R & D in agriculture, as opposed to an area where we do not have enormous surpluses and there we are reducing."[11]

Ability of Forest Service Research to Attract Outside Funding

As congressional appropriations for Forest Service Research have declined over the past several years, the Forest Service has reemphasized its efforts to attract research funds from outside sources--various Federal, state and local governments, the forest products industry, universities, foreign governments and others. The ability of a Federal agency to attract research funding outside the appropriations process is a measure of its competitiveness, i.e., the relative attraction of its scientific talent and facilities versus those of alternative research performers.

Forest Service Research employs six mechanisms for obtaining outside support to augment its appropriated research funding. These are:

- Competitive grants
- Research contracts with industry
- Research funding from other Forest Service units
- Research contracts from other Federal agencies, state or local governments
- Participation in research consortia
- Organization of not-for-profit corporations

Competitive grants are sought by Forest Service scientists from grants programs of one of the federal government departments. Typically, supplementary funds are sought to augment appropriated funds so that the research can be accelerated or expanded. The Forest Service scientist prepares a research proposal in the customary way and submits it to the granting agency for evaluation in competition with scientists from universities and other research organizations. In other cases, Forest Service personnel may participate in research proposals submitted by scientists in other organizations, and receive support from such outside grants.

The primary grant program utilized by Forest Service scientists is the USDA Forestry Competitive Research Grants program (officially titled the Competitive Grants Program for Forest and Rangeland Renewable Recources) established by the Congress in 1985. From FY 1985 to FY 1987, Forest Service scientists who applied as Principal Investigators received grant funding for 37 proposals under this program, totalling $4.04 million in funds. (See Table 5). (More details on this competitive grants program are found in the following section of this report.)

Forest Service researchers also apply to grants programs of other agencies, including the National Science Foundation (NSF), the National Institutes of Health (NIH), EPA, the Department of Housing and Urban Development (HUD), the Department of Energy (DOE), and USDA (other than FS). The amount of grant funding awarded to Forest Service Research Stations from these sources was $447,000 during the FY 1985-87 period.

TABLE 5: FY 1985-1987. Totals of Outside Funds Received to Directly Support Forest Service Research Programs

SOURCE	1985	1986	1987	3-year Total
	($1,000)			
1. Competitive Grants	1,064	1,844	1,576	4,484
2. Other Forest Service	5,242	6,133	6,787	*18,162
3. Other Federal Agencies	5,219	9,539	9,673	24,431
4. State Government	957	822	1,040	2,819
5. Other Governmental	145	95	584	824
6. Private Sector	744	1,178	1,655	3,577
7. Miscellaneous**	324	385	481	1,190
YEARLY TOTALS	$13,695	$19,996	$21,796	$55,487

* $6,279 total from the Tongass Timber Supply Fund
**Foreign, Public Utilities, Universities

SOURCE: STATION DATA

Research contracts with industry are signed by the Forest Service with individual firms or industrial associations which wish to have a specific problem studied and desire FS research expertise rather than contracting with another research performer. It is possible that the Forest Service will provide supplementary or matching funds for the research if it is a subject of active research interest. The industry benefits by having the research done, by receiving a license to use the results at no additional cost, and by learning the results prior to their public dissemination. During the FY 1985-87 period, the Forest Service received $3.58 million in research funding from industry and other private sector sources.

Other Forest Service units, e.g., the National Forest System, may wish to obtain assistance from Forest Service Research in studying a specific problem for which no funding, or insufficient funding, exists in the Forest Service Research appropriation. In such cases, unit funds may be used to "contract", formally or informally, with an FSR station. This can be considered as outside funding for Forest Service Research, as it augments their available funds much as an industrial contract does. During the FY 1985-87 period, $18.2 million in funding came from this source, including $6.3 million from the Tongass Timber Supply Fund.

Other Federal agencies also may contract with Forest Service Research for studies. Some agencies, e.g., Bureau of Land Management, Soil Conservation Service, do not conduct research and look to the Forest Service and other research performers to meet their research needs. In the FY 1985-87 period, funding from other Federal agencies amounted to $24.4 million, and represented the largest source of outside funding.

State and local government agencies also contract with the Forest Service for research funding. These contracts amounted to $3.6 million during the FY 1985-87 period.

Research consortia are three-way partnerships of industry, universities, and Forest Service Research established to conduct research in a specialized research area. Examples are the Biopulping Consortium and the planned Sawblade Consortium, each involving the Forest Products Laboratory (FPL), the University of Wisconsin and several industrial firms. The industrial firms provide the research funding and the Forest Service and universities provide the research facilities and staff expertise.

Not-for-profit corporations can be organized with Forest Service Research involvement to work in specific scientific areas. The prototype not-for-profit corporation is the Institute of Meteorology and Allied Sciences, established and operated by Federal, state, university and industrial representatives. The Institute, governed by a board of trustees, operates through a series of permanent committees composed of members of each of the founding groups to determine research needs and attract funding, primarily from private foundations but also from state and private organizations.

Table 5 shows the sources and amounts of outside funds that directly supported Forest Service Research programs over the last three fiscal years. The outside funding has grown in each of the years and in FY 1987 was about one-sixth as large as that year's research appropriation.

Success in Competition for Grants

The USDA Competitive Grants Program for Forest and Rangeland Renewable Resources provides a means of measuring the competitiveness of Forest Service Research. Through this program, Forest Service Research scientists can prepare research proposals and compete directly for funding with scientists in universities and industrial research laboratories. Grants are made in two scientific areas: improved harvesting, processing and utilization of timber resources; and fundamental forestry biology, including biotechnology. All qualified scientists in the U.S. are eligible to compete for grants, including federal scientists.

The Forestry Competitive Grants Program in administered by the USDA Competitive Research Grants Office in the Cooperative State Research Service. The procedures for awarding grants are based on a competitive evaluation process used by the National Science Foundation. Scientists on leave from their institutions serve as program managers or evaluation panel members.

Over the three years of the program, FY 1985-FY 1987, Forest Service Research scientists received 23 percent of the grants awarded, representing $4.04 million or 21 percent of the total grant funding. The affiliations of the scientists receiving grants is shown in the following tabulation:

Organization	FY 1985 Grants	FY 1986 Grants	FY 1987 Grants	3 Year Total
Universities	39	47	33	119
Forest Service	14	15	8	37
Industry	1	1	2	4
Total	54	63	43	160

Data from the Grants Administration Management Office of CSRS appear to show that Forest Service Research has a substantially greater ratio of success in receiving grants, based on applications submitted, than does the remainder of organizations competing. Applications from "Other [than USDA S&E] Federal Research Laboratories" are believed to be all from FSR, so during the FY 1985-1987 period FSR had 37 of 175 applications (21.1 percent) awarded. All other applicants (e.g., universities, state experiment stations, and USDA S&E) had 123 of 995 (12.4 percent) grant applications awarded.[12]

Professional Journal Authorships

Authorship of articles in professional journals, particularly refereed journals, is a traditional measure of competitive standing in the research community, as well as of contributions to scholarship. It is not a perfect measure of scientific stature or competitiveness because it relies on quantitative measures rather than the quality of the research contribution. Nevertheless, it provides an objective indication of scientific research activity.

Forest Service Research staff directors identified 35 scientific journals as the primary journals of interest to the Forest Service program areas--an indication of the breadth of Forest Service research interests.[13] Seven journals were selected for analysis of the degree of Forest Service authorship, based on their relative prestige in one of the Forest Service program areas. They are:

Journal of Forestry
Forest Science
Journal of Economic Entomology
Journal of Range Management
Journal of Wildlife Management
Water Resources Research
Soil Science

Recent issues covering a multi-year period were analyzed for six of the journals to determine the proportion of articles by authors affiliated with the Forest Service. The analysis of Soil Science was limited to the eleven issues, January - November 1987, then abandoned when no Forest Service authors were found.

Overall, Forest Service authors contributed more than one-seventh of the articles in the other six professional journals. This is an impressive proportion of articles, particularly considering the relatively small number of Forest Service Research staff compared with those in other organizations active in the same scientific fields (i.e., universities, other federal, state and local agencies, and industry). Most of these journals have an international readership and publish articles from authors throughout the world's scientific community.

As might be expected, the highest percentage of articles by Forest Service authors is found in the specialized forestry journals--35 percent of articles in the Journal of Forestry and 35 percent of articles in Forest Science. Lesser percentages of authorships are found in more specialized scientific journals representing disciplines or programs in which relatively few Forest Service Research staff are employed: 7 percent in Journal of Range Management; 6 percent in Journal of Wildlife Management; 3 percent in Journal of Economic Entomology; and 2 percent in Water Resources Research.

An attempt was made to normalize the data on authorships by indexing the percentage of articles by Forest Service authors to the percentage of Forest Service professional research staff among total U.S. scientists, by discipline. This attempt has been only partially successful because there is little consistency among the data sources in categorization of occupational/disciplinary specialties.

- FSR personnel records, as of 12/31/87, categorize 919 research scientists (a group that includes about 200 professional support staff) into 35 occupational series. Degree of educational attainment is not indicated.

- The National Science Foundation's Science and Engineering Personnel: A National Overview (NSF 85-302), 1985, categorizes scientists and engineers into 22 occupational fields, subdividing

them by employed/unemployed; primary work activity; type of employer; and doctoral/total. NSF's occupational fields are not detailed. For example, Forest Service Research occupational series include: General Biological Science; Microbiology; Ecology; Entomology; Botany; Genetics; Fishery Biology; and Wildlife Biology. NSF has only the category "Biological Scientists."

- USDA Forest Service General Technical Report WO-29, Criteria for Deciding About Forestry Research Programs (1981) categorizes Federal employees in resource-related disciplines into 42 categories, closely related to the FSR occupational series, and identifies the number of full-time employees, by category, in five major agencies (FS, BLM, F&WS, SCS, and NPS) and in the entire Federal Government, as of 1977.

Despite these problems, some data have been used for normalization. However, the normalization of the authorship data is imprecise because the authors of articles in a professional journal span more than a single scientific discipline.

Two observations made during the analysis are notable. First, more than two-thirds (68 percent) of the co-authored articles were collaborations of Forest Service staff and persons with other organizational affiliations. This is evidence that Forest Service Research is not insular but involves substantial outreach and scientific interaction. Additional evidence of outreach was found by Jakes and Fege[14] whose study of 1,750 multi-authored publications showed that Forest Service authors were more likely to co-author a paper with someone outside the Forest Service than with someone within their own unit.

The second observation was that 15 authors identified themselves as "Forest Service (Retired)" and two others as "ex-Forest Service". This can be interpreted as reflecting a pride in the reputation of Forest Service Research as well as indicating the continuing desire for scientific contribution of Forest Service retirees.

Details of the analyses of the journals follow.

Journal of Forestry. During three years (1985-87), the Journal of Forestry published 249 authored articles. Of these, 86 articles (35 percent) had at least one co-author with a Forest Service affiliation. The remaining articles had a sole author or first co-author with the following affiliation:

97 articles (39 percent)--University
16 articles (6 percent)--Industry
9 articles (4 percent)--State or local government agency
8 articles (3 percent)--Other Federal agency
33 articles (13 percent)--Other

Ten authors identified themselves as "Forest Service (Retired)" and two as "ex-Forest Service."

Of the 86 Forest Service-authored articles, 30 were written by a single author. The remaining 56 articles had the following Forest Service co-authorship:

30 First co-author
35 Second co-author
12 Third co-author
4 Fourth co-author
1 Seventh co-author
82 Total co-authors affiliated with Forest Service

Forest Science. Over the past three years (1985-87), Forest Science published 288 articles. Of these, 102 (35 percent) had an author or co-author(s) affiliated with the Forest Service. The remaining articles' authors have the following affiliations:

158 (55 percent)--University
13 (5 percent)--Industry
10 (3 percent)--Other sources
4 (1 percent)--Other Federal agencies
1 (0 percent)--State or local govt. agency

Of the 102 articles with Forest Service authors, 29 had a sole author. The remaining articles had co-authorships distributed as follows:

48 First co-author
40 Second co-author
21 Third co-author
Fourth co-author
1 Fifth co-author
117 Co-authors affiliated with the Forest Service

NSF does not indicate the number of foresters or forestry scientists in the U.S. The Society of American Foresters has 19,956 members. Forest Service General Technical Report WO-29 shows that there were 5,395 foresters employed full-time by the U.S. Government in 1977. At year-end 1987, Forest Service Research employed 306 foresters. This indicates that FSR employs about 6 percent of U.S. Government foresters and about 1.5 percent of all foresters in the U.S. Thus, FSR authorship or co-authorship of 35 percent of articles in the Journal of Forestry and Forest Science indicates a high level of scientific scholarship.

Journal of Range Management. In 1986 and 1987, 270 articles appeared in the Journal of Range Management, of which 20 (7 percent) had at least one author or co-author affiliated with the Forest Service. Authorship of the other articles was distributed as follows:

156 (58 percent)--University
56 (21 percent)--Other Federal agencies
21 (8 percent)--Other sources
15 (6 percent)--State or local govt. agency
2 (1 percent)--Industry

Five of the Forest Service articles had a single author. The other 15 articles had co-authorships distributed as follows:

12 First co-author
12 Second co-author
4 Third co-author
1 Fourth co-author
29 Co-authors affiliated with the Forest Service

The Society of Range Management has about 5,700 members, according to the 1987 Encyclopedia of Associations. [The Society's headquarters telephone in Denver had been disconnected before June 1988.] NSF does not indicate the national total of range managers. FS General Technical Report WO-29 shows that 1,093 range managers were employed full-time by the U.S. Government in 1977. Forest Service Research employed 22 staff in "range conservation" as of 12/31/87. A rough estimate suggests that FSR employs from 0.4 to 2.0 percent of all range managers in the U.S. This authorship or co-authorship of 7 percent of articles in the Journal of Range Management is a significant indicator of scientific scholarship.

Journal of Wildlife Management. During 1986 and 1987, 284 articles appeared in the Journal of Wildlife Management. Eighteen of the articles (6 percent) had one or more Forest Service authors. The remaining articles were authored as follows:

179 (63 percent)--University
32 (11 percent)--Other Federal agency, e.g., F & WS
27 (10 percent)--Other sources
26 (9 percent)--State or local government agency
2 (1 percent)--Industry

Two of the Forest Service articles had a sole author. The remaining 16 articles had the following co-authors:

10 First co-author
8 Second co-author
3 Third co-author
1 Fourth co-author
22 Co-authors affiliated with the Forest Service

NSF does not distinguish the number of wildlife managers or scientists among the 225,200 "biological scientists" in the U.S. in 1983. The Wildlife Society, publisher of the Journal of Wildlife Management, has 8,100 members. Forest Service General Technical Report WO-29 reported 1,055 wildlife biologists, 198 fish and wildlife administrators, 462 refuge managers, and 124 zoologists employed full-time by the U.S. Government in 1977, a total of 1,839 persons. At year-end 1987, FSR employed 41 wildlife biologists. This gives a rough indication that FSR employs from 0.5 to 1.0 percent of wildlife scientists in the U.S. Thus authorship/co-authorship of 6 percent of the articles in Journal of Wildlife Management suggests a disproportionate degree of scientific scholarship in FSR.

Water Resources Research. For the most recent issues available (January 1986-November 1987) 509 articles were published in Water Resources Research. Eight articles (2 percent) had at least one Forest Service co-author. The remaining authorships were distributed as follows:

358 articles (70 percent)--University
57 articles (11 percent)--Other Federal agencies (e.g., USGS)
54 articles (11 percent)--Other sources, incl. foreign organizations
26 articles (5 percent)--Industry
6 articles (1 percent)--State or local government agency

Of the eight Forest Service authored articles, four were written by a single author. The other four had the following co-authors:

2 Second author
3 Third author
5 Co-authors affiliated with the Forest Service

Journal of Economic Entomology. During 1985 and 1986, the Journal of Economic Entomology published 669 authored articles, of which 18 (3 percent) had an author or co-author with a Forest Service affiliation. The affiliation of the authorships of the remaining articles is as follows:

372 (56 percent)--University
195 (29 percent)--Other Federal agencies, e.g., ARS
49 (7 percent)--Other sources
27 (4 percent)--State or local government agency
8 (1 percent)--Industry

The 18 articles by Forest Service personnel had the following distribution of authorships:

1 Sole author
14 First co-author
14 Second co-author
5 Third co-author
3 Fourth co-author
1 Fifth co-author
38 Authors affiliated with the Forest Service

The Entomological Society of America has 9,200 members. There were 758 entomologists employed full-time by the U.S. Government in 1977, according to General Technical Report WO-29. FSR employed 66 entomologists at year-end 1987. Roughly estimated, FSR employs from 1 to 3 percent of all U.S. entomologists. The authorship/co-authorship of 3 percent of articles in the Journal of Economic Entomology indicates that FSR equals or exceeds other organizations in scientific scholarship in entomology.

Professional Journal Citations

Whereas authorship of articles in professional journals measures the quantity of contributions to scholarship, the quality of the research

contributions is generally measured by the number of times the article is cited in subsequent articles and books by other authors. Such citation is considered evidence that the article is noteworthy and serves an an authority for subsequent research findings.

Through reference to the Science Citation Index,[15] a count was made of all articles by Forest Service authors which were cited in the world's scientific journals during a five year period, 1980-1984, the most recent five year period for which data are available. The analysis covered articles written by Forest Service authors at selected locations: the eight Experiment Stations, the Forest Products Laboratory, the Washington Office, the Northeastern Area (Broomall, PA) and the nine regional offices. It is believed that the authors cited are or were primarily in Forest Service Research, but some other Forest Service authors probably are included.

In every case, the citation is to the first author only; other articles in which the Forest Service author is a second (or subsequent) co-author are not included, so the count of citations is understated. The analysis in the prior subsection of this report shows that of 252 journal articles with some Forest Service authorship, in 187 the sole author or first co-author were Forest Service members. This suggests that the undercount of citations may be in the range of 35 percent, i.e., for every 100 articles cited, another 35 citations may have unrecognized Forest Service co-authors.

Altogether, 2,198 citations to FS-authored articles appeared in 1980-84. The number attributed to each locality, i.e., the locality and affiliation used by the author in each article that was subsequently cited, is as follows.

Locality	No. of Citations
ALABAMA:	
Auburn (30)	10
ALASKA:	
Anchorage (PNW)	7
Fairbanks (PNW)	29
Juneau (PNW, R-10)	21
ARIZONA:	
Flagstaff (RM)	7
Tempe (RM)	7
ARKANSAS:	
Monticello (SO)	4
CALIFORNIA	
Arcata (PSW)	6
Berkeley (PSW)	128
Fresno (PSW)	15
Redding (PSW)	2
Riverside (PSW)	9
San Francisco (R-5)	12
COLORADO:	
Fort Collins (RM)	120
Lakewood (R-2)	8
CONNECTICUT	
Hamden (NE)	52

DISTRICT OF COLUMBIA	
Washington (WO)	41
FLORIDA	
Gainesville (SE)	23
Olustee (SE)	17
GEORGIA	
Athens (SE)	77
Atlanta (R-8)	9
Dry Branch (SE)	4
Macon (SE)	15
HAWAII	
Honolulu (PSW)	22
IDAHO	
Boise (INT)	11
Moscow (INT)	19
ILLINOIS	
Carbondale (NC)	32
Chicago (NC)	0
KENTUCKY	
Berea (NE)	9
LOUISIANA	
Alexandria (SO)	5
New Orleans (SO)	11
MAINE	
Orono (NE)	12
MASSACHUSETTS	
Amherst (NE)	3
MICHIGAN	
East Lansing (NC)	14
Houghton (NC)	7
MINNESOTA	
Duluth (NC)	6
Grand Rapids (NC)	18
St. Paul (NC)	60
MISSISSIPPI	
Gulfport (SO)	67
Oxford (SO)	3
Starkville (SO)	4
Stoneville (SO)	24
MISSOURI	
Columbia (NC)	14
MONTANA	
Bozeman (INT)	2
Missoula (INT, R-1)	20
NEBRASKA	
Lincoln (RM)	7
NEVADA	
Reno (INT)	8
NEW HAMPSHIRE	
Durham (NE)	53

NEW MEXICO	
Albuquerque (RM, R-3)	6
NEW YORK	
Syracuse (NE)	2
NORTH CAROLINA	
Asheville (SE)	28
Durham (SE)	1
Franklin (SE)	4
Otto (SE)	15
Raleigh (SE)	6
Research Triangle Park (SE)	12
OHIO	
Delaware (NE)	46
OREGON	
Bend (PNW)	6
Corvallis (PNW)	150
LaGrande (PNW)	21
Portland (PNW) & (R-6)	56
PENNSYLVANIA	
Broomall (NE) & NA (S&PF)	14
University Park (NE)	3
Warren (NE)	9
PUERTO RICO	
Rio Piedras (SO)	21
SOUTH DAKOTA	
Rapid City (RM)	8
TENNESSEE	
Sewanee (SO)	0
TEXAS	
Nacogdoches	10
UTAH	
Logan (INT)	5
Ogden (R-4, INT)	52
Provo (INT)	25
VERMONT	
Burlington (NE)	11
WASHINGTON	
Olympia (PNW)	16
Seattle (PNW)	4
Wenatchee (PNW)	13
WEST VIRGINA	
Morgantown (NE)	5
Parsons (NE)	12
Princeton (NE)	10
WISCONSIN	
Madison (FPL)	420
Milwaukee (R-9)	0
Rhinelander (NCL)	82
WYOMING	
Laramie (RM)	11
Total	2,198

This substantial number of citations reflects a broad geographical dispersion of significant articles by FSR authors, and represents an average of about two citations during the period for each Forest Service Research scientist.

Leadership in Professional Societies

Election to leadership posts in professional societies is in part a measure of professional stature and recognition and in part a sign of willingness to serve the profession. The same is true with appointments to one of the posts as associate editor of the society's professional journal.

While the appearance of Forest Service members' names on lists of professional society officers and journal editors is an indication of stature in the professional research community, it does not serve as a measure or index of competitiveness unless it is normalized. Therefore the authors attempted to normalize these data by obtaining data on membership, i.e., full membership rather than student memberships, from the appropriate professional societies and relating this to the data on Forest Service research personnel by scientific discipline. This attempt was successful only in the case of the Society of American Foresters.

Society of American Foresters. Forest Service Research has 919 professional staff, of whom at least 216 are members of the SAF,[16] which has a membership of 19,956. Although no Forest Service staff serve as national officers (4) or Council members (11) of the SAF, two members of NFS, Region 9, are in national leadership posts. Charles J. Newlon serves on the 8-member Forest Science and Technology Board, and John J. Vrablec is Chairman of the House of Society Delegates. Nine of the nineteen members of the Advisory Board of the SAF's refereed journal Forest Science are with Forest Service Research: Dean S. DeBell, Richard E. Dickson, David A. Hamilton, Jr., Stephen B. Horsley, Rolfe A. Leary, Donald H. Marx, Robert A. Monserud, Arthur R. Tiedemann, and William E. Wallner. The Journal of Forestry, also published by the SAF, does not indicate an Advisory Board or group of Associate Editors.

Society of Range Management. The Forest Service has 22 staff classified as Range Conservationists, but it is not known how many others are involved in range management activities, or how many FS staff are among the 5,700 members of the Society of Range Management. No Forest Service staff are among the 10 officers and directors of the SRM but one, Thomas A. Hanley, serves as an Associate Editor of the Journal of Range Management.

Entomological Society of America. There are 66 entomologists among the professional staff of the Forest Service. It is not known how many of these are among the 5,700 members of the Entomological Society of America. Of the 16 Directors of the Society and the four members of the Editorial Board of the Journal of Economic Entomology, none is a Forest Service staff member.

Soil Science Society of America. The Forest Service has 26 employees who are categorized as soil scientists, an unknown number of whom belong to the Soil Science Society of America, which has 6,000 members. None are among the four officers of the Society, but two (Jon M. Geist and Robert F. Powers) are among the 42 Associate Editors of the Society's Journal.

American Geophysical Union. The Forest Service is not represented among the 29 Associate Editors of the interdisciplinary journal, Water Resources Research.

Summary of Findings

An attempt to summarize various pieces of evidence on the competitiveness of Forest Service Research reveals several major strengths and certain weaknesses, not all of which appear easy or even possible to remedy. Certainly an outstanding reputation for excellent quality of scientists and research accomplishments is a preminent aspect of competitiveness. The reputation is supported by such measures as scientific publication authorship, citations in scientific journals, and leadership in professional societies.

The Forest Service is not competitive in obtaining congressional appropriations, when compared to most major R&D performeres or even the other USDA agencies. To some degree, the Forest Service has compensated for this by obtaining a growing amount of supplemental funding from outside sources.

Subjective measures of FSR competitiveness, such as the perceptions of FSR scientists and research managers, users of FSR research, competitors, and other knowledgeable observers, are discussed in the Task V Report, Analysis of Perceptions of Forest Service Research Competitiveness, included as Appendix H.

ENDNOTES

[1] USDA Research and Education Committee, 1986 Annual Report on the Food and Agricultural Sciences from the Secretary of Agriculture to the President and the Congress of the United States, September 1987, pp. 2-7.

[2] USDA Forest Service Briefing Book for 1988 Congressional Budget Hearings, p. 9.

[3] National Science Foundation, Federal R & D Funding by Budget Function, Fiscal Years 1966-68, March 1987, pp. 67, 68, 73.

[4] Ibid., pp. 1, 94.

[5] Ibid., pp. 4, 14, 16, 24.

[6] John Fedkiw, Associate Director, Office of Budget and Program Analysis, Office of the Secretary, USDA, "Research Evaluation and Policymaking", in Forestry Research Evaluation: Current Progress, Future Directions, General Technical Report NC-104, 1985, pp. 5-6.

[7] Ibid., p. 8.

[8] Ibid., p. 11.

[9] Ibid., p. 12.

[10] U.S. Congress, House of Representatives, Committee on Appropriations, Subcommittee on the Department of the Interior and Related Agencies, Hearings, . . . Appropriations for 1988, April 22, 1987. Washington: GPO, p. 899.

[11] Ibid., p. 904.

[12] Discussion and correspondence with Terry J. Pacovsky, Head of Grants Administration Management Office, USDA-CSRS, June 21-22, 1988.

[13] The most recent version of the annual publication on Forest Service research accomplishments identifies 32 research disciplines grouped into six broad research categories. Making Our Forests and Rangelands More Productive: 1985 Research Accomplishments, General Technical Report WO-52, September 1986, pp. iii-iv.

[14] Pamela J. Jakes and Anne S. Fege, "Co-Authorship Patterns of USDA Forest Service Research Scientists at Two Regional Experiment Stations, 1981-1984," in IUFRO Proceedings, Evaluation and Planning of Forestry Research S6.06-S6.06.01, Colorado State University, Fort Collins, Colorado, July 25-26, 1985 (NE-GTR-111) Northeastern Station, USDA, Forest Service, p. 104.

[15] Science Citation Index, Five Year Cumulation 1980-84, Corporate Index, Geographic Section (3 vols.). Philadelphia, PA: Institute for Scientific Information, 1986.

[16] An SAF membership analysis of May 1, 1988 shows 3,140 members who are Forest Service employees. Of these, 216 categorized their positions as "researchers/educators." This is 8.9 percent of the total SAF membership categorized as "researchers/educators." Other FSR staff members may have categorized themselves as "management," or other positions.

Appendix H

STUDY PROJECT:
ASSESSMENT OF THE COMPETITIVENESS OF FOREST SERVICE RESEARCH

Task V: Analysis of Perceptions of Forest Service Research Competitiveness

May 1, 1988

Task V: Analysis of Perceptions of
Forest Service Research Competitiveness

Introduction

The Task IV Report, completed January 15, 1988, contained an assessment of the competitive standing of Forest Service Research based on six objective measurements. After a brief review of Task IV findings, this Task V Report will assess competitive standing based on one additional measurement--the ability to recruit and retain scientific staff. This report next will present and analyze perceptions of outside observers and their subjective views of Forest Service Research competitiveness, as expressed in personal interviews by the study team.

In Task IV, the following characteristics were measured objectively and analyzed:

Congressional willingness to fund Forest Service Research
Ability of Forest Service Research to attract outside funding
Success in competition for grants
Professional journal authorships
Professional journal citations
Leadership in professional societies.

The Congress has been less willing to fund Forest Service Research than other USDA research programs, based on an analysis of appropriations between FY 1979 and FY 1987. While the combination of all other USDA research programs gained 2.0 percent in constant 1979 dollars (i.e., purchasing power) during this period, Forest Service Research shrank by 14.8 percent in constant dollars.

Forest Service Research has fared much worse when compared with appropriations for the four most favored R & D programs that collectively receive 92 percent of the federal R & D budget: national defense; health; space research and technology; and general science.

Only when compared to the relatively unfavored group of natural resources and environment agencies does Forest Service Research manage to hold its own in appropriations. Yet this group's funding was reduced by 5 percent from FY 1987 to FY 1988.

It is clear that Forest Service Research has not been competitive in obtaining congressional appropriations over the past eight or nine years. It is not so clear what the reasons may be; whether congressional perception of the quality of accomplishments and of management, or congressional (or departmental, or administration) perceptions that the program and mission of Forest Service Research are less important than those of other federal agencies. Another possible reason is a relative lack of institutional support and/or political support. These questions will be discussed later in this Task V report.

The ability of Forest Service Research to attract outside funding has grown in response to reemphasized efforts to attract research funds from outside sources--various federal agencies, state and local governments, the forest products industry, universities, foreign governments and others. Total outside funding has grown from $13.7 million in FY 1985 to $21.8 million in FY 1987, when it was about one-sixth as large as that year's research appropriation. This ability to attract outside funding is a measure of competitiveness because it reflects the relative attraction of Forest Service Research scientific talent and facilities versus those of alternative research performers.

Success in competitions for grants, i.e., the Forestry Competitive Research Grants Program administered by USDA Cooperative State Research Service, is an objective measure of the competitiveness of Forest Service Research scientists. All qualified scientists in the U.S. are eligible to compete. Over the three years of the program, FY 1985-FY 1987, Forest Service Research scientists received 23 percent of the grants awarded, representing $4.04 million or 21 percent of the total grant funding. FSR scientists received grants from 21.1 percent of applications submitted, a much higher success rate than the 12.4 percent rate achieved by their competitors.

Professional journal authorships, particularly of papers in refereed journals, is a traditional measure of competitive standing in the research community. It relies on quantitative measures rather than measuring the quality of the research contribution, although the referee review process does screen out papers of least merit. Analysis over a multi-year period of six journals selected for their relative prestige in one of the Forest Service program areas showed that more than one-seventh of the articles had Forest Service authors or co-authors. This is an impressive proportion of articles, particularly considering the relatively small number of Forest Service Research staff compared with those in other organizations active in the same scientific fields (i.e., universities, other federal, state and local agencies, and industry). Most of these journals have an international readership and publish articles from authors throughout the world's scientific community.

Professional journal citations are indicators of the quality of research contributions, as measured by the number of times an article is cited in subsequent articles and books by other authors. Such citation is considered evidence that the article is noteworthy and serves as an authority for subsequent research findings. Through reference to the Science Citation Index, a count was made of articles by Forest Service authors which were cited in the world's scientific journals during a five year period, 1980-1984, the most recent five year period for which data are available. There were 2,198 citations during this period, an average of about two citations for each FSR scientist.

Leadership in professional societies and appointments to associate editor posts of a professional society's journal indicate stature in the professional research community that is substantially greater than the proportion of society membership affiliated with the Forest Service.

Ability to Recruit and Retain Scientific Staff

The ability to recruit and retain scientific staff is central to maintenance and improvement of scientific quality, a major aspect of competitiveness. The study team interviewed numerous scientists hired by the Forest Service during the 1985-1988 period to obtain their perceptions on the relative desirability of a Forest Service career compared with other employment opportunities. Interviews also were conducted with project leaders, station directors and assistant directors, and personnel officers to learn about offers made and rejected, with reasons for non-acceptance, and about resignations of junior scientists. During interviews with several deans and department chairmen in forestry schools, information also was obtained on their views and their graduate students' views of a Forest Service research career.

Currently, there is a buyers' market for Ph.D. scientists in most disciplines. The Forest Service does not lack for qualified applicants although some offers are rejected by scientists who prefer alternate careers, such as university faculties. Most of the recently hired Ph.D.'s had considered offers from other employers, including universities, industry or state forestry departments, before selecting the Forest Service's offer. However, for some in certain overstaffed specialties such as entomology or silviculture offers were rare and they consider the Forest Service their best or only opportunity.

Those who chose Forest Service Research careers generally had a favorable opinion based on some prior knowledge of the Forest Service, such as experience as temporary hires or as graduate students working on cooperative projects. Several mentioned having an experiment station or regional office near a university that they attended. These scientists had a favorable prior opinion of the Forest Service. Others had never thought of the Forest Service as a possible career and a very few had a negative opinion related to advice from their professors. Yet these accepted Forest Service offers because of subsequent exposure to a Forest Service research project that they came to admire. Others chose the Forest Service because of limited alternative opportunities, such as a desire for employment in a specific location where a spouse was employed.

Those who declined offers reportedly did so for a variety of reasons, such as inferiority of laboratory equipment compared to that at a university, or receipt of an offer in a tenure-track faculty position. More commonly applicants and recruited candidates have grown weary of the several month delay caused by the federal recruitment, evaluation and certification process and have accepted an alternate offer. A Forest Service Personnel Manager stated that "The length of the Federal recruitment process is a major obstacle to recruitment. It isn't limited to scientists but is very acute there. From the time we have an opening identified and the job described, it takes four to five months to work through the ARS 'Uniform Guidelines on Employee Selection Procedures', OPM, Justice, OMB, et al. and they require rather sophisticated evaluation techniques. We are pushing hard for direct hire categories [i.e., increasing the number of positions for which we may

make job offers directly without going through the central screening and certification process]. We have this for certain categories such as engineers. We aren't sure it will happen, but it would permit us to act now rather than after several months delay. Timeliness is more important than [amount of] pay."

Recently hired scientists, both on temporary and permanent appointments, mentioned many advantages to Forest Service Research employment. Most frequently mentioned was the opportunity to conduct exciting research, in some cases unique research, and to work with well-respected scientists. Freedom to pursue research they like is important, as is support from several peer scientists (in stations that have enough scientists in their field to form a critical mass--not all have enough). Relatively high starting salaries for new scientists was mentioned occasionally but not considered as important as other factors, such as research freedom and adequate budgets to conduct research of choice. Encouragement to publish, good support services (e.g., graphics, statistical consultation) and ready access to land, data bases and field stations were mentioned favorably. One scientist indicated that since the station was as competitive academically as a top university, she appreciated the absence of a "tenure crunch" which would have required extra preparation time and severely limited her time with her husband and baby.

Among disadvantages, the most common complaints were: (a) among non-minority temporary hires, the perception that they have little or no opportunity to be hired permanently (this is discussed at more length below); and (b) the lack of amenities they valued during university graduate study, including access to a good library, access to seminars, the ability to sponsor graduate students and to interact with faculty. Other disadvantages mentioned were bureaucratic restrictions on personal freedom, i.e., mandated activities that interfere with research such as writing study plans, staff and committee work. Some complained of travel restrictions, both the difficulty in receiving permission for travel to international conferences (including Canada and Mexico) and budget constraints that limit conference attendance unless it has been planned well in advance.

The lack of academic amenities is particularly acute in those stations and laboratories that are relatively remote from a university and its library. However, it was mentioned as a source of dissatisfaction even at the Berkeley station which is two blocks from the University of California campus but "that it is too far to drop in next door and interact." A very common recommendation by younger scientists is that the Forest Service should co-locate stations and laboratories on university campuses to remove a perceived restriction on the quality of research conducted outside an academic environment. (Some forestry deans and chairmen have made similar suggestions, as will be discussed later in this Task Report.)

Limited number of job openings. A characteristic of Forest Service Research is the lengthy tenure of its scientists, typically for an entire career. With a research budget that has been static or declining in purchasing power in recent years, long tenure results in relatively few job openings for new scientists. Openings occur primarily for reasons of

retirement, with some resignations and some layoffs due to cutbacks in certain research programs. The limited number of job openings has negative effects on the ability to recruit the most desirable younger science graduates into Forest Service Research. With limited openings, candidates are less likely to consider a Forest Service career, are less likely to know a recently-hired Forest Service scientist to serve as role model, and are less likely to have their graduate faculty recommend applying to the Forest Service. Furthermore, disuse erodes the networks between Forest Service research managers and universities that serve as sources to recommend candidates to fill job vacancies. This could, over time, reduce the number of top candidates that can be recruited by the Forest Service.

Post-doctoral scientists on term appointments. The employment by the Forest Service of post-doctoral scientists on term appointments appears to have grown significantly in recent years. This can be beneficial because it allows the Forest Service more time to know and evaluate the scientist than merely an initial year's probationary period before awarding permanent status. Even if the position is intended as a temporary one, it does provide a revitalization to the scientific unit. However, the willingness of post-doctoral scientists to accept temporary appointments is, to a substantial degree, a function of the job market. Except for a few who value the opportunity to gain experience in Forest Service Research before moving on to a more favored position, most temporary post-doctorals say that no opportunities for a permanent research post can be found. They are ambitious, concerned about the absence of benefits, such as medical insurance for their families, and many consider that their chances of a permanent appointment in the Forest Service are very remote. One scientist stated that he was in his second post-doctoral post since graduation; longer sequences of post-doctoral posts were mentioned. The Forest Service is attempting to improve their hiring policies on post-doctoral scientists. They already have obtained authority to make direct-hire offers for appointments of up to two years duration (soon to be changed to four years) and efforts are underway to pay benefits to temporary employees and approval is expected soon. These steps will doubtless improve the ability of the Forest Service to recruit top post-doctoral scientists now and during future changes in the job market.

Senior research vacancies. Although the Forest Service is very competitive in recruiting younger scientists, they have more difficulty hiring in senior positions such as project leaders with specialized experience. This is due in part because persons experienced in operations research, chemistry, prescribed fire and economics are in short supply or are more strongly attracted to universities that pay higher salaries than GS-13 or GS-14 for comparable persons.

Affirmative action hiring constraints. The Forest Service is making a strong effort to implement its policy (and that of the USDA) to diversify its traditionally White male staff by increasing the percentage of women and minorities. The announced goal is "To have a work force that is representative of the civilian workforce at all levels,"[1] in its proportional representation of minorities, women, and handicapped employees.

Implementation of the policy in Forest Service Research results in an

extended effort by each station to identify affirmative action candidates through contacts with universities and to encourage their application. That much is generally understood and approved throughout Forest Service Research. However, there is widespread perception that the policy is much more rigid than the traditional affirmative action practices that exist in universities and industries with government contracts. As one temporary post-doctoral scientist put it, "The image among the universities and post-docs is that the Southeastern Station is unfair and positively discriminates against White males. This is not fair to anybody including the women and minority hires who are viewed as being hired on a discriminatory basis and thought less than qualified even if they are." Similar views were heard at each of the stations visited. Another temporary post doctoral scientist stated, "The different hiring philosophies in Forest Service Research are of concern particularly to me as a White male. I am a temporary. I don't consider this job a very stable one. I am continually looking for other job opportunities. [Another post-doc] and I are on annual appointments. [This research] unit cannot offer permanent jobs to White males and is losing them to universities or industry. The Forest Service has established fixed quotas to attain the same percentages of minority and women as exist in society, not their ratios in the forestry profession, and this makes it very difficult to fill jobs."

Whether or not these perceptions are accurate, they are widespread among temporary scientists who are White males. If inaccurate, as they appear to be from talking with a few White males recently given permanent appointments, they are a definite deterrent to White males who are potential candidates for Forest Service employment.

Even the perceptions of hiring policy among project leaders reflect concerns. One project leader said that the station must not fill any permanent jobs until a woman or minority candidate is identified. This can take up to a year to make a search and recruit them. "In practice, if the certification doesn't put an EEO in the top three, they reject the certification. It is so restrictive that it has put us in deadlock. If we cannot hire people, it takes away our incentive to hustle soft money. We have EEO Committees, Wellness Committees--everything except research."

Another project leader said, "Concerning your question on the problems faced by the Forest Service in acquiring staff with expertise in newly emerging research areas, we encounter tremendous delays in personnel hiring responsiveness. The concern with diversity also presents problems because forestry has traditionally not been a field pursued by women or minorities. The concerns of temporary employees are widespread and very real." However, he contradicted a comment that the policy establishes quotas of hiring to meet the diversity of the general population: "Quotas are very bad. I am not certain how it works but I am told that White males are not excluded. The way it works is that we are to do a very thorough affirmative action search, but when the top three are certified we can pick the best."

Perceptions of Forest Service Competitiveness Held by Knowledgeable Observers

The authors of this report have conducted interviews not only with Forest Service administrators and research scientists but with persons from other organizations who are believed knowledgeable about Forest Service Research, its competitiveness, quality, responsiveness to changing needs, etc.

Categories of observers who have been interviewed by the study team include the following:

- o Executives of federal research organizations that interact with Forest Service Research and/or use its research results
- o Executives of forestry organizations, trade associations and professional societies
- o Executives of the USDA and its agencies outside the Forest Service
- o Deans and department chairmen of university schools of forestry
- o Representatives of OMB and the staffs of the Senate and House Appropriations Subcommittees
- o Executives of the Forest Service outside Research, in the Washington Office and some field locations
- o Executives of Forest Service Research in the Washington Office and four Experiment Stations.
- o Project leaders and scientists in four experiment stations

Thus far, 126 persons have been interviewed by the study team. They were assured that their comments would not be attributed to them unless subsequent permission was granted. The study team has chosen to keep quotations anonymous, identifying only the category of the respondent.

Views on Scientific Competitiveness of the Forest Service

A large majority of persons interviewed had high praise for the quality of Forest Service Research, even though certain shortcomings of FSR also were discussed frankly in many of the interviews. Moreover, some categories of respondents have shown a less favorable view of FSR scientists and their research quality, as discussed below.

The widespread excellent reputation of Forest Service Research among knowledgeable persons in peer groups is commendable and a factor of major significance to the competitiveness of the agency. However, the critical views of some persons familiar with FSR and with the broader scientific community should be given appropriate attention.

Executives of federal research organizations, forestry organizations and USDA agencies had a high opinion of Forest Service scientists and their research. These opinions were given without reservation, even when certain other aspects of Forest Service Research were criticized, as discussed below. The extent of this excellent reputation for quality can be conveyed in brief comments from the interviews:

- o Forest Service Research does excellent work. Their peer review is a standard setter. The quality of their research is excellent and the quality of the scientists is excellent also. [A Federal agency user of FS research]

- o Despite the limitations they face as an agency, I have been impressed with the level of dedication to their profession. This is an asset to preserve and build on. They are a bunch of fine men. [A Federal research administrator]

- o The quality of Forest Service Research is generally excellent, and they periodically move into new research areas. Our people do of course use their published research results. [A Federal agency user of FS research]

- o I have a very high regard for Forest Service Research scientists. [A USDA agency official]

- o The quality of research done by the Forest Service is as good as that done anywhere, but the perception of it may be lower. The Forest Service has a smaller peer review group and has not tried to compete with the larger NAS groups. There are plenty of top-notch researchers in the Forest Service. [A USDA agency official]

- o Forest Service Research is the preeminent forestry research organization despite budget cuts. [A forestry professional association executive]

Some Forest Service research managers and scientists have expressed degrees of criticism of their organization, such as acknowledging that some scientists are relatively unproductive and that others conduct research in areas that have faded in importance. Several expressed concern that Forest Service Research has lost some outstanding scientists without replacement by equally promising younger scientists. The problems of an aging scientific staff, obsolete facilities and equipment, and lack of operational funds were widely mentioned as threats to scientific quality. Several mourned the erosion or discontinuance of some of the long-term research programs in silviculture and forest management which had been central to achieving the reputation of Forest Service Research. Despite this critical concern for the future, however, the overall view was one of pride in the accomplishments and reputation of the agency, tempered with considerable concern over funding and other trends that threaten this reputation.

Interviews with representatives of OMB and the Appropriations subcommittee staffs did not cover in depth the perception of scientific competitiveness. Allusions to research quality, while neutral to favorable, were overshadowed by discussions of shortcomings in presenting a case for increased funding for FSR.

By far the most negative views of the quality of Forest Service Research scientists and scientific accomplishments came from interviews with deans and

department heads of university forestry schools. That is not to say that this group of 16 respondents was uniformly critical--all praised aspects of Forest Service Research and three of the deans expressed quite favorable opinions of Forest Service competitiveness. However, the criticisms made were sharp and were often illustrated with examples and anecdotes. Some examples of comments follow:

- o In my judgement, Forest Service Research is excellent and certainly competitive in a scientific sense.

- o At the present time the Forest Service is not strong in much of anything. They have weakened severely in the last ten years. I am not sure why but the curtailment of funding certainly contributed to this. It is a good organization with great potential and with some of the finest equipment and facilities in the country. I am saddened to see how much it has declined.

- o There are not that many of their research areas are terribly weak but many that are just O.K. The Forest Service is spread thin over many areas with an aging group of scientists. They have been hanging on the ragged edge in terms of funding. New initiatives are proposed internally or by Congress yet no new money is appropriated. They are undermanned.

- o There is a general lack of peer respect for Forest Service Research scientists. When we search for candidates for our faculty we derive a list of the top candidates who are the best known scientists in their field. We rarely if ever find the name of a Forest Service Research scientist on the list. In the academic area, Forest Service Research is not considered top rank. We rarely call on Forest Service Research scientists as peer reviewers to help us select faculty candidates.

It should be noted that the critical nature of the deans' comments varied geographically. Deans from one region of the U.S. were the most critical while deans at universities in an opposite region were relatively favorable to FSR. This may possibly reflect a variance in scientific quality between experiment stations.

Despite examples of harsh criticism, the deans generally expressed a desire to see the Forest Service recover perceived losses in research competitiveness and had numerous suggestions as to the cause of these losses and recommendations on how to improve.

Reasons for Perceptions

Respondents mentioned several reasons for their views on Forest Service research competitiveness which are discussed in this section.

Breadth of research programs. Forest Service Research frequently has been viewed as a broad, multi-disciplinary organization that has the role of the

nation's (some say the world's) leader in natural resources research. (However, there is dispute over what the agency's mission is or should be, as is discussed later.) To several observers, Forest Service Research can no longer fill this role. Through lack of resources and a resulting lack of research vitality because of inability to recruit top scientific talent into an aging staff, an overall decline in competitiveness has occurred. University deans, in particular, speak of a shift of research leadership from the Forest Service to the universities in several scientific areas. In some cases, this is because the Forest Service has shifted resources from some areas to accommodate others. One dean paralleled the decline of Forest Service Research leadership to a decline in U.S. technological leadership in forest science: "The U.S. is being eaten alive by the technological development in Scandinavia, particularly Sweden and Finland. At a recent pulp and paper conference I noticed that all of the innovative machinery comes from overseas. The most treasured wood pulp in the world is coming from Brazilian eucalyptus. We are being out-researched and outranked."

There is a perception that, unless Forest Service Research appropriations increase, the agency should cut out some of its programs and concentrate on others. Of those proposing this, most suggested keeping and augmenting the long-term basic research programs and letting applied research go to industry and universities. For example:

- o The Forest Service should restore and maintain long-term do-able research that builds a base; for example the Forest Hydrology Lab at Coweeta. The universities are more into the cut and run type of research. If the Forest Service also gets into the cut and run research who will do the long-term? The Forest Service needs much stronger appropriations, not grants from the Competitive Grants Program. [A university dean].

- o The long term studies of black spruce silviculture; of natural stand management; Pearson's ponderosa studies; the work on forest stands at Corvallis with OSU; and fire studies on the Francis Marion Forest in South Carolina are examples of especially worthwhile Forest Service research achievements. The universities would never have given the continuity needed for these studies because the funding that universities receive is not steady. Only the Forest Service can conduct these long-term studies. Unfortunately the Forest Service is cutting out all of them although some are kept alive by very dedicated people who maintain them even though they have been shifted to other missions. Sometimes in setting research priorities we overlook work which is being done very well at the moment and is very important. Such work doesn't come out as a priority. The priority setters are concentrating on new areas to look into and they don't mean that the very valuable ongoing research should be dropped, but when the priority list comes out the long-term research is not on it." [A forestry department head].

Clarity of mission. The study team asked many persons within the Forest Service, not only in research but also in NFS and S & PF, what they viewed as the mission of Forest Service Research. There was no common view. Responses

ranged from national leadership in the broad category of natural resources research, at one extreme, to conducting research (including short-term tactical research) and transferring existing technology to provide answers to NFS management problems, at the other. Most responded with some combination of these mission statements. There also were comments on the role of conducting basic research vs. applied, although nearly everyone stated that some mixture of the two was necessary. Some acknowledged that technology transfer was an expected aspect of the mission. No consensus exists.

The lack of unanimity does not surprise the study team, for lack of consensus as to mission is relatively common in complex organizations. In this case it emphasizes the variety and breadth of roles that those within and outside the agency look to Forest Service Research to play. It may be that the agency is expected to be many things to many people, in addition to having an internal vision of striving for scientific preeminence.

The comments of several observers on lack of competitiveness and the need to restrict the agency's research programs appear based on recognition that the Forest Service cannot perform its myriad roles with excellence, given the resources allocated to it.

Organizational visibility. Forest Service Research has always been relatively small; even when there were as many as 1,100 scientists in the agency, it constituted a good deal less than 10 percent of the Forest Service. FSR is small in numbers compared with the university forest science community. Because of its organizational location two levels below the Secretary, in contrast is ARS and ERS, for example, it receives less visibility than many other agencies and bureaus. Some may view it as an appendage of the National Forest System which typifies the popular image of the Forest Service. Some of the general public do not know the agency exists. Further, because many of its research activities are oriented to forestry, even though they may be fundamental advances in basic science, they tend to be overlooked by the general science community. These factors limit the visibility of Forest Service Research and research scientists and certainly detract to some degree from the image of FSR scientific competitiveness.

Level of institutional support. Some observers in positions promoting political awareness have remarked on the relatively low level of political support given Forest Service Research within the Department of Agriculture. Such comments imply that there has been little involvement by the Chiefs over the past several decades with respect to Forest Service Research, which was said to have gotten little or no representation at the Secretary level through the natural resources channels. Even though FSR has been viewed as a national resource in the area of natural resources research, that area itself is considered undervalued, particularly in the last several years. Organizationally placed within a Department of Agriculture with a strong commodity orientation, even the accomplishments of FSR are undervalued. It is perceived that ARS research directed toward improved crop production or elimination of a food crop or livestock pest is valued more highly than long-term improvements in silviculture or control of a tree moth or beetle, or research on non-timber uses of forests.

This lack of institutional support is, naturally, perceived as limiting the funding requested for Forest Service Research in the USDA budget. It is evident, as shown in the Task IV Report (Appendix G), that Forest Service Research fares poorly compared to the agricultural research agencies. A similar disparity exists between national forestry research funding and agricultural research funding. One of the deans commented that: "Overall there is a lack of forestry funding. I am on a research campus which has a College of Agriculture. The research funding for forestry is $6.7 million a year, mainly in soft money. The research budget for the Agricultural College is $60 million a year. There are 47 accredited forestry schools in the U.S., all competitors for too small an amount of research funding. Even yet the only appropriated federal funding for forestry is in McIntyre-Stennis funding which amounts to $70 [sic] million dollars a year. Our share is $400,000, less than enough to support 2-1/2 scientists.

Resource constraints. The recent history of Forest Service Research funding has been described in the Task IV Report (Appendix G). It is widely perceived inside and outside the agency as a major factor deterring research competitiveness, although not the sole factor. The reduced level of funding is not the only constraint. Respondents have remarked also on the constraints put on by OMB and by the Congress in earmarking of funds. Others commented on the uncertainty of funding that is dependent on an annual political process rather than appropriations of "no year" funds that can aid research planning and management. Several pointed out the harsh impacts of a political decision to cut back severely on Forest Service research in the early 1980's: "Under the first Crowell budget in 1982, there was a 20 percent cut in staffing. No one had ever seen anything like this before." There is a general feeling within Forest Service Research that there is little hope in the near term that funding will improve significantly except when relative emergencies, e.g., a pest outbreak, occur or when the Forest Service can participate in a research area of national concern, e.g., acid rain.

Resource allocation decisions. Respondents frequently commented, often critically, on certain resource allocation decisions that they feel are unwise and injurious to research quality. However, the criticisms frequently were contradictory, emphasizing the difficulty of making resource allocations that please everyone. For example, recommendations to close or consolidate facilities to concentrate on priority programs were heard, as were complaints about cutting back on such programs as fire research at Macon and phasing out experimental forests. A frequent criticism was of the relatively high percentage of budgeted funds tied up in staff salaries, leaving relatively little for operational support. This, again, can be viewed as a decision to maintain a long-term investment in scientists during a period of low funding, and to increase efforts to obtain outside funding for operations. Rather sour minority comments were made by two university forestry department heads. One stated, "I never felt that the agency was under-administered. Despite budget cuts there are plenty of station directors, assistant directors, secretaries, etc." Another used a colorful simile to deride the uselessness of assistant station directors for planning, adding that they are "used as gofers by the Station Director," and of the assistant directors who serve as

research area administrators "who are accomplishing nothing on their march to the Washington Office."

Level of research entrepreneurship. Rather mixed criticisms were made by university forestry administrators concerning the perceived level of entrepreneurship of Forest Service scientists. "Forest Service research has a problem in not having enough scientists who are competitive. They have been secure in the past and are not motivated to write proposals and compete for funding. The track record of Forest Service research scientists is not good. Some are disillusioned and have approached us about faculty positions where they would not feel the same pressure to write grant proposals. They are very poor in grantsmanship. However, I am not sure I want them to be competitive. There have been some slight negative thoughts among our faculty over the pressures put on Forest Service Research scientists to be competitive."

Responsiveness to user needs. The responsiveness of Forest Service Research to user needs received some criticism, although this was often balanced by acknowledgement that there is a compensating strength. That is, that much of the FS research strength is in long-term research, often at the margin of scientific knowledge, and that this strength would be eroded if Forest Service scientists needed to respond swiftly to short-term tactical problem-solving. One Federal user agency spokesman described Forest Service Research as a "stabilizing force conducting research to a plan but they are sometimes slower than we like and do not give us the priority we expect in contracted research." Another agency spokesman acknowledged that research should be deliberate and should not be too rapid in responding to change, but noted a problem: "If everything that someone wants from you takes three years to deliver, you cannot build client support."

Some observers attributed the level of responsiveness to the tendency of Forest Service Research to tie up a large proportion of its funding in staff salaries and in existing facilities, which means that it is difficult to move rapidly into new research areas that require funds to hire new technological talent. In contrast, universities can move more rapidly to put graduate students to work on new problems. The relatively long tenure of FSR scientists also contributes to reduced ability to shift research fields, although this again was viewed as a contributor to overall quality and stability of the FSR long-term research program. The reduction of research funding in recent years was mentioned as a factor in limiting FSR's ability to move into new programs. The Forest Service work in acid rain research was praised by some persons as a leading example of responsiveness, but it was pointed out that this new program was made possible only by the appropriation of new funds, not by internal shifts of program priorities. [This is only partly accurate; some FSR funds were reallocated to acid rain.]

Suggestions were made on ways to improve FSR responsiveness by enhancing scientific interaction and interchange, thus overcoming some of the problems inherent in long staff tenure and limited funding. One suggestion was to consider emulating a recent program of the Agricultural Research Service which offers increased opportunities for post-doctoral students. The same suggestion was made by a National Science Foundation scientist who suggested

that in a resource-limited world, NSF has brought in post-doctoral scientists on term appointments, thus utilizing the crop of new Ph.D.s who have nowhere else to go. He suggested that adopting this policy would create a future cadre of scientists who are very loyal to the Forest Service and are potentially able to assist them. Another suggestion was to encourage more Research Station/university cooperatives which create an environment of mutual leverage and intellectual stimulation. Greater use of the Intergovernmental Personnel Act (IPA) to promote scientific interchange was proposed, but the constraints placed by the Administration on the use of IPA were acknowledged as a barrier. A final suggestion made was to increase the use of sabbatical leaves as an interchange mechanism. This would involve providing matching funds to university professors to spend their sabbaticals within the Forest Service, and also sending Forest Service Research scientists into universities on sabbaticals, as the National Science Foundation, NASA, and possibly the National Institutes of Health do.

Limitations in technology transfer. A frequent criticism of the Forest Service Research program, although by no means a universal criticism, was of its limitations in technology transfer. Such criticism was expressed by representatives of a federal user agency, a USDA agency representative, and by an executive of a professional forestry association. However, another federal science observer felt that this is an unfair criticism and noted, "I think they are spread very thin through extension work."

Critics of FSR technology transfer gave several examples. One federal agency spokesman said that FSR "really falls down in technology transfer," and commented that the rewards are strongly oriented to research accomplishments and publications, with no rewards for technology transfer. He criticized the failure to give attention to transmitting their findings and spoke of his inability to obtain and disseminate to his field people a list of FSR results and publications so they would be aware of FSR findings. He spoke of the unavailability of any central publication that describes all of the FS research results, apparently unaware of the existence of the annual Research Accomplishments report (WO-52). While remaining critical of the technology transfer effort, he stated that "if you seek out the scientists they are very helpful and have the best information base in natural resources that I know of."

A USDA agency representative agreed that the FSR area most needing improvement is the rapid transfer of technology. He alluded to a study by the Northeastern Area, Forest Service, on needs assessment which found that an "amazing" number of current needs could be met by research already completed and "sitting on the shelf." He acknowledged some successful FSR efforts in technology transfer but commented that a formal linkage is needed back to the land grant university. He suggested that the FS technology transfer organization should be located near the land grant university's forestry school with close links to State and Private Forestry, not at the Regional Office.

Decentralization of research activity. A distinctive characteristic of Forest Service Research is its decentralization of activity among many experiment stations and laboratories while maintaining a planning system that

coordinates activities into a national program. Obvious advantages of decentralization include visibility and convenient access to NFS and S & PF regional staff needing assistance on regional problems. Decentralization traditionally has helped the Forest Service garner political support from state and local forestry interests and from Congressmen in whose districts stations and laboratories are located.

The drawbacks to decentralization are related to isolation of research staff, lack of sufficient peer scientists to form a critical mass in several laboratories, and the resulting negative effects on research quality.

Research agenda planning and selection process. A variety of criticisms were made by observers relating to the process of planning and selection of the research agenda. These criticisms differed among categories of observers. Criticism of the difficulty of shifting research priorities, with resulting inflexibility of the agenda, was frequent. These criticisms were most often made by officials of forestry professional associations than by the user agencies. One commented that less emphasis is needed on how to grow more trees, since there is no timber shortage, but more emphasis is needed on how to improve the quality of wood and wood products and how to improve the competitiveness of these products in world markets while maintaining the environment. Another federal agency official commented that the Forest Service does not do enough social research or make use of research done elsewhere on sociology and on the management of people who use the forests. He attributed this in part to an indication of "not invented here" in Forest Service Research, and also to the influence of the Forest Service's traditional orientation to agriculture rather than to ecosystem management.

Among deans of forestry schools, there was wide agreement that they had little influence on development of the Forest Service's research agenda. One remarked, "Forest Service Research planning is taking an internally directed approach to setting their agenda. Formerly there were research planning group efforts which gave a real structure for the Forest Service, universities, and industry to have influenced agenda. These group efforts have declined in the past eight years. I have less influence now than some eight years ago."

Another dean commented, "My own view is that they could use more outside help in establishing their research agenda. It is now not influenced by anyone outside Forest Service Research except for the Congress."

Related to their comments on agenda setting were the critical comments of the deans related to decisions on research programs they consider unwise. The consensus of these is that Forest Service Research has neglected some long-term basic research projects that should have been continued, to continue the flow of innovations necessary for successful applied research. Further, that the Forest Service conducts some applied research that will never be utilized, failing to ask in advance, "If I am successful with this research task, will anyone use it?" Finally, some deans criticized the Forest Service for being "too little, too late" in entering some emerging and important fields such as biotechnology, because of its resource constraints and inflexibility in shifting its research agenda. One commented, "The

Forest Service is not on the cutting edge of science. For example they attempted to get into biotechnology (genetic and molecular). The universities have taken an important lead in this field. The Forest Service is trying to catch up partly by retreading older scientists. We know firsthand that biotechnology programs are extremely expensive and I don't see how the Forest Service can hope to succeed in this area. The same is true with atmospheric deposition. The universities took the lead, not the Forest Service. The Forest Service came in later with EPA funds and some Forest Service funding was transferred from other programs, some badly needed. It is an awkward and difficult situation."

Research autonomy. The autonomy of scientists to work in areas of their own choosing was mentioned both as a strength and a weakness of Forest Service Research. The perceptions of the actual degree of autonomy as well as the ideal degree of autonomy differ. Although scientists are officially circumscribed by their RWU description, it appears that they are given some latitude to do research that does not strictly fall within the description. For example, some stations maintain a grant fund to make small competitive grants to scientists for small research projects of their interest.

Those critical of the degree of autonomy given to scientists often relate it to the perceived weakness in technology transfer activities. They note that many scientists look on technology transfer as an interference with their science and successfully resist engaging in it. At the other extreme, incidents are reported in which scientists are diverted almost entirely from their RWU research to work on problems of concern to NFS which lobbies the station director or the Chief to obtain the scientist's services.

However, one of the deans suggested greater autonomy as a spur to improved scientific quality and creativity: "They have a cumbersome bureaucracy. The Forest Service should look at the Bell Labs model. Top people must have time to do what they love. At Bell Labs their scientists get 25 percent free time and free money plus the use of Bell Labs' facilities to work on research of their own interest. The other 75 percent they work on problems that Bell Lab assigns. Bell Labs has made a study and determined that the real innovations that made them piles of money came from these hobby projects rather than the formal research projects that they instituted.

Quality control. The quality control process used within Forest Service Research is based on peer review. This begins with review of research plans to assure statistical validity and replication. It includes provisions for statistical consultation at the station, editorial review by technical editors, and finally peer review within the station before publication or submittal to a refereed journal. (However, this requirement is being relaxed in at least one station to reduce pre-publication delays; authors are permitted to submit manuscripts directly to refereed journals, perhaps after an internal review by colleagues.) Some respondents have praised it as a model for other research agencies and have related it to the FSR reputation for high quality research. However, two disquieting criticisms of the quality control system were evident during the interviews.

The first was by a university forestry department head who is active as an editor and reviewer of refereed journals, who stated: "The Forest Service has a way of moving its dead wood out of the way but even the dead wood continues to conduct research, even poor quality research. Mediocre people accept mediocre work. The peer review of publications within the Forest Service is in my opinion inadequate. Once, I got a Forest Service Research paper to review and rejected it for publication in a journal. Later, I got the same paper back sent to me as a reviewer and I returned it to the editor with a comment. Then the paper appeared after being sent to still a third journal and a colleague and I wrote back a letter to the editor giving the history and urging that it be rejected. The editor received a nasty letter from the Head of Forest Service Research saying, 'we invested $10 million dollars over three years in this work and it deserves to be published'. What he did not understand is that the experiments had no replication and the value of the research was negligible."

The second criticism is that the Forest Service quality control system is not adequate for high visibility national research programs such as the atmospheric deposition program, and that because of this inadequacy, the Forest Service is not competitive with EPA to obtain Congressional funding for such programs.

A knowledgeable observer (from outside the Forest Service) explained: "When the Forest Response program was put together, the EPA said that research was required to be quality-assured. The Forest Service did not have a QA program, so agreed that Northrop would implement QA on behalf of EPA and the Forest Service. This had been a concern to Forest Service Research but is now accepted. There is a historic problem: the Forest Service's [negative] perception of the way EPA does its QA. (EPA can and doesy remove people's funding if the quality is not kept up.) EPA's work plan is very complete (up to 1/2 inch thick) and contains specific criteria on experimental design and a detailed quality assurance plan. This is what EPA looks at to design the work to known accuracy and precision so it can defend the work in litigation. In contrast, the Forest Service develops a very general and brief (maximum two pages) study plan and expects that quality will be built in by peer review. The detailed EPA study plan allows the peer reviewer to know when data is expected to be obtained and what its specifications must be, etc. Under EPA rules, the Forest Service scientist must produce a detailed study plan to be approved for funding to begin with.

"The Forest Response program administration is set up as a joint Forest Service/EPA project and there are EPA and Forest Service equivalents who sign off on each other's funding packages. If EPA and Forest Service parted ways, I am convinced that the Forest Service would drop QA immediately. The Forest Service, which has a history of forestry research, is not competitive to get funding from Congress, which wants data of known quality, developed in a finite period on which they can base decisions and pass public scrutiny. EPA has stepped in to fill this gap. EPA implements QA for analytical labs to measure and attribute affects of air and water pollution. EPA has now extended its QA system to biological processes. My recommendation to the Forest Service is to institute a QA program similar to EPA's and get a mind set to accept five year research projects with specific goals if the Forest

Service is to compete for this type of funding. EPA will end acid rain in two years. EPA has already positioned themselves to go into the next program: ozone effects. EPA Corvallis has already done a lot of the documentation for the ozone program, has a QA program in place and has a pilot program on ozone at Corvallis already funded. Meanwhile the Forest Service lab at Corvallis (which is larger) is essentially empty and under utilized."

Analysis of Organizational Attributes Affecting Competitive Standing

During the interviews, numerous attributes of the Forest Service Research organization were described and linked, positively or negatively, to the competitive standing of FSR. These attributes will be divided into two major categories: attributes external to FSR, imposed from outside and largely beyond its control except for possible attempts to seek outside assistance; and attributes internal to FSR which are more or less within its control although some changes may require concurrence from higher levels. After categorization, the attributes will be briefly described, if necessary. (Some have been discussed earlier in this Task Report.)

Next, the attributes will be separated into gradations of high or low impact and positive and negative impact, based on the study team's subjective judgment.

Finally, the high-impact negative attributes will be identified and alternative ways to modify high-impact negative attributes internal to Forest Service Research will be discussed. A discussion of possible ways to modify high-impact negative attributes external to FSR will be deferred to the final study report.

Attributes external to Forest Service Research. The following attributes, largely outside the control of the agency, all have negative impacts on the perceived competitiveness of Forest Service Research:

- **Resource limitations.** The existence of annual research appropriations, while providing a reasonable stability of funding that is envied by research organizations heavily dependent on soft money, is offset by the uncertainty of funding levels and their dependence on political climate. Also, recent funding levels are considered seriously inadequate to support the Forest Service Research mission, or rather missions. Overall, this is considered a high-impact, negative attribute.

- **Level of institutional support in USDA.** This has been discussed on pages H-11 and H-12, above. Although this would appear largely outside the control of FSR to improve, there have been criticisms from persons in key positions that Forest Service Research has not made the best case for its program, and has not sought support from outside the USDA or outside the federal government that is ready and able to support its program. Because institutional support is so closely

linked to appropriations, this must be considered a high-impact, negative attribute.

- **Limited organizational visibility.** This also has been discussed on page H-11, above. FSR's visibility is limited both within the USDA and within the general scientific community (which includes the influential Washington, D.C. scientific community, largely federal, and the broader scientific community which comprises universities and industry). This limited visibility directly impacts perceptions of competitiveness and indirectly impacts institutional support and, in turn, appropriations. This is considered a medium-impact, negative attribute.

- **Federal personnel regulations.** The Forest Service is necessarily subject to regulations of the Office of Personnel Management and also to the hiring process for life scientists described on page H-3, above. Four attributes impacting scientific competitiveness are perceived to result:
  1) long tenure of permanent staff, following a one-year probation period, which provides stability of employment (barring reductions in force) for the productive and unproductive alike and limits job openings for new scientists;
  2) emphasis on affirmative action/equal employment opportunity which, as implemented within the USDA/Forest Service, is seen as a severe constraint limiting much of the hiring to a small fraction of the pool of scientists in the work force. The implications of this policy on Forest Service research can be observed from Table 1, prepared by the study team from NSF data;
  3) slowness of the hiring process, described on pages H-3 and H-4;
  4) difficulty in giving financial incentives and rewards to outstanding scientists, as might be done in universities and industrial laboratories.

It is recognized that OPM is not inflexible and that exceptions can be made

TABLE 1. Doctoral Scientists in the Labor Force, by Selected Field, by Sex, Race and Hispanic Status, 1983

Selected Field	Male	Female	White	Black	Asian	Other[1]	Hispanic Status[2]	Total
Statisticians	2,500	300	2,300	*	400	*	*	2,800
Computer Specialists	10,900	1,300	11,000	*	900	200	200	12,200
Earth Scientists	11,900	700	11,800	*	600	100	200	12,600
Biological Scientists	45,100	11,100	50,300	700	4,300	900	700	56,200
Agricultural Scientists	14,000	700	13,500	100	800	200	300	14,700
Economists	15,600	1,400	15,100	300	1,300	400	300	17,000
Chemists	38,300	3,600	36,800	400	3,900	700	700	41,900
Atmospheric Scientists	2,100	100	2,100	*	100	*	*	2,200
TOTALS	140,400	19,200	142,900	1,500	12,300	2,500	2,400	159,600
Percent	88.0%	12.0%	89.5%	0.9%	7.7%	1.6%	1.5%	100.0%

Source: National Science Foundation, Science and Engineering Personnel: A National Overview (NSF 85-302), Washington, D.C. 1985.

*Too Few Cases to Estimate

[1]Includes Native American, other, and no report.

[2]Hispanic Status is not a racial category; Hispanics also are included in "White", "Black", and "Other" as appropriate.

to its regulations when sufficient justification exists. Yet, the process of obtaining exceptions is more difficult than in most scientific organizations. The federal personnel regulations are considered to be a medium- to high-impact negative attribute.

Attributes internal to Forest Service Research. The following attributes which are generally within the control of FSR are perceived as affecting competitiveness. Some are positive, some negative, others mixed or in dispute:

- **Lack of agreement on research mission.** The lack of clarity or agreement on the FSR mission is discussed on pages H-10 and H-11, above. To many observers, it appears that the agency is expected to fill many roles for many people, with inadequate resources to do so and with institutional constraints that exacerbate the problem. This is a high-impact, largely negative attribute. However, in a limited sense this can be considered a positive attribute--the sign of a research agency ambitious to achieve broad scientific pre-eminence but whose reach exceeds its grasp.

Three alternative ways to respond to this problem can be identified. The first is continuation of the status quo, i.e., to leave the mission definition ambiguous and broad and to attempt to cover all the bases through a refined process of agenda planning and resource allocation that provides for an optimum, though admittedly inadequate, solution. This can be termed the optimistic alternative; its strategy is to hold the organization and mission reasonably intact until a time when resources become more adequate.

The second, or aggressive alternative, is to leave the mission definition ambiguous and broad and to mount a strategy to enhance appropriations of funds so that the resources will match the breadth of the mission. This requires ways to modify a high-impact negative attribute external to FSR--a topic deferred until the final report.

This third, or defensive alternative, is to undertake a soul-searching analysis of the mission of FSR, probably in consultation with others including NFS and S & PF, USDA, the Congress and the forestry community. This can result in a redefinition of mission, one more narrowly bounded than at present, and one that better fits the levels of appropriations that are expected in the future.

- **Internally-developed research agenda.** Forest Service Research has been criticized (see pages H-15 and H-16, above) for developing its research agenda internally, after some consultation with others but with the final judgement supplied by FSR. This is a mixed, or disputable attribute. The negative aspects relate to the perception by universities and others, perhaps including industry, that their recommendations are ignored and their influence is low. Such opinions are not likely to stimulate the political support badly needed for improvement of the level of FSR appropriations. However, stressed as FSR is by a mission too broad for its funding, it appears

understandable that FSR leadership should decide which bases to cover and which to leave open, since it must face the consequence of these decisions.

Until the central question concerning the mission of Forest Service Research is answered, it seems premature to explore alternative ways to respond to the question of how, and by whom, the research agenda should be developed. The answer to the first will heavily influence the answer to the second.

- **Decentralization.** This topic was discussed on pages H-14 and H-15, above. It is a mixed, or disputable attribute. While it is included among the internal attributes, there certainly are strong forces in the Congress that limit FSR from responding by centralizing some facilities and closing others. Decentralization can be viewed as a medium-impact negative attribute at present levels of funding, but one with low- to medium-impact positive results in terms of stimulating political support.

One alternative way of correcting one of the perceived drawbacks of decentralization--remoteness from a critical mass of scientists and scientific tools, e.g., libraries, is to co-locate more regional facilities on the campuses of universities having similar scientific departments. One dean of a forestry school made the case for this: "The Forest Service has tried to scatter its facilities on a state by state basis rather than concentrating on some and cooperating more with universities. We are starving for research funds and the Forest Service is also. We should join hands. They should co-locate scientists on university campuses where they can have access to graduate students and interact with the faculty. Their productivity would be much higher. Synergism would grow." Another forestry department head states a similar opinion and said, "The work of Franklin and OSU in Corvallis is a good example of this. You get a multiplier effect."

- **Emphasis on research publication vs. technology transfer.** The topic of technology transfer was discussed on page H-14, above. The view is widespread among Forest Service scientists that, despite contrary assurances in the FS manual, the all-important paneling process that determines promotion and financial reward is wholly based on a research publication record. This is not considered a serious problem by many scientists, for research and publication is what scientists do, and what they like to do. The reward system promotes scientific productivity and indirectly promotes organizational visibility and thus competitiveness. From this viewpoint, this emphasis on research and publication is a high-impact positive attribute. However, from the standpoint of responsiveness to user needs it has negative impacts.

This again is a question that is secondary to the central question of the FSR mission. Until it is determined what the mission is--natural resources research leadership, the provision of technological support to NFS and other users, or both--it is premature to consider fundamental changes in the system of motivation and reward for scientists. If the answer to the mission

question is "both", one alternative way of responding is a structural one. That is, to strengthen the responsiveness of Forest Service Research by adding or transferring persons skilled in technology transfer, including State and Private Forestry units, into a co-location with FSR stations and laboratories so they can interact with scientists and serve as a transfer agent to users.

- **Process of planning and resource allocation.** The formal process of planning, preparation of five-year RWU descriptions, and allocation of resources by line item has been described by several observers as an attribute that limits flexibility and competitiveness. It is this perceived inflexibility that is viewed by some as the cause of Forest Service Research failing to enter new scientific fields of importance until others, e.g., universities, have taken a scientific lead. Others, in contrast, say that the strength of the Forest Service is the ability to give long continuity to certain research programs rather than chasing new fads. This is a mixed or disputable attribute. While inflexibility to modify an RWU description could certainly limit research competitiveness, the FSR planning process does allow for annual modifications of the RWU descriptions, and efforts are made to give scientists latitude to work outside that description, as discussed under "Autonomy" on page H-16, above.

This is another attribute that is linked to the question of what the Forest Service Research mission should be. The mission decision affects the development of research agenda, which in turn affects the process of planning and resource allocation. Until the mission is determined, it seems premature to consider ways to modify the current planning and resource allocation process.

- **Quality control.** The quality control process used within Forest Service Research is described on pages H-16 to H-18. It is the traditional system used in universities, except more formalized and with the addition of specialized statistical and editorial support. It is the cornerstone of scientific quality and thus key to competitiveness. It has evidently served the Forest Service well in the past. Although the criticisms described earlier are by only two of the many respondents, they appear persuasive. Therefore, this is viewed as a mixed, or debatable, but high-impact attribute.

If Forest Service believes that the criticisms are valid, the ways to correct them are apparent. The decision to implement a formal, "aerospace program-type" quality assurance program of the EPA model would be a considerable departure from traditional peer review. Yet, it may be a very necessary step as a prerequisite to participation in future research programs having national prominence and high visibility to the Congress.

- **Level of research entrepreneurship.** This topic was discussed in the Task IV report (summarized on page H-2, above) and briefly on page H-13, above. The empirical evidence of the ability of Forest Service Research to attract outside funding from various sources, including the Forestry Competitive Research Grants Program, is positive. It

outweighs the subjective view of a single university dean. Thus, entrepreneurship is considered as a medium-impact positive attribute

- **Esprit de Corps.** An attribute not previously discussed but one that became evident during interviews and station visits, is the esprit de corps of Forest Service Research. One assistant station director, in describing the agonizing personal problems associated with the fire reorganization decisions, said: "The Forest Service is a family organization and we usually treat people well. This was an exception." This sense of sharing and personal consideration appears to be a very positive benefit to any organization, and a particular asset to a decentralized agency dedicated to scientific achievement and support. It more than compensates for the occasional inefficiency that may arise from allocating a large portion of the budget to staff salaries, to retain scientists during low-funding periods. It is considered as a low- to medium-impact positive attribute.

Summary of Findings

An attempt to summarize various pieces of evidence on the competitiveness of Forest Service Research reveals several major strengths and certain weaknesses, not all of which appear easy or even possible to remedy. Certainly an outstanding reputation for excellent quality of scientists and research accomplishments is a preminent aspect of competitiveness. Observers in federal agencies, forestry organizations and industry credit the Forest Service with that reputation, and it is supported by such measures as scientific publication authorship, citations in scientific journals, and leadership in professional societies. However, several university forestry deans and department heads had sharp criticism of FSR scientists and their research, stating that the former research strength of the Forest Service has eroded through inadequate funding, aging of staff and inadequacy of its scientific quality control. And its scientific leadership has passed to the universities. (Interestingly, their appears to be a geographical pattern to the deans' comments; favorable opinions of Forest Service Research are concentrated in one sector of the U.S. while the most critical are grouped among universities in the opposite sector.)

The competiveness of Forest Service Research is threatened by weaknesses in its ability to recruit scientific staff. This is related to the limited number of job openings, delays in the hiring process, and affirmative action hiring constraints.

The Forest service is not competitive in obtaining congressional appropriations, when compared to most major R&D performers or even the other USDA agencies. To some degree, the Forest Service has compensated for this by obtaining a growing amount of supplemental funding from outside sources.

Nevertheless, it is universally perceived that the funding of Forest Service Research is inadequate to support its traditional programs and to enter new research areas. There is no consensus on what the mission of Forest Service Research is, or should be, but it lacks the resources to both

maintain leadership in natural resources research and to support the NFS in research and technological support.

Perceptions of outside observers indicate some weaknesses that may reduce the competitiveness of the Forest Service Research program. One is a perception of limited responsiveness of FSR to the needs of users, combined with a deliberation of research pace that is viewed as a slowness in technology transfer program is weak and thus hampers users' utilization of the excellent research accomplishments of the Forest Service.

It is apparent that competiveness of Forest Service Research would be enhansed if the technology transfer program were improved, and this also would be likely to enhance the perception of responsiveness to user needs. How much improvement can be achieved in view of the decline in funding of Forest Service Research is uncertain.

Strengths in research quality are essential and irreplaceable elements of organizational competitiveness, and the base on which necessary improvements can be built. These remain relatively strong in the eyes of most outside observers. But they agree that the weaknesses described above will take their toll if some resolution is not reached in the near future.

ENDNOTE

[1] Work Force 1995: Strength Through Diversity, Washington, D.C.: USDA Forest Service, December 1987, p. 5.